SOCIAL AND NON-SOCIAL INFLUENCES ON THE BEHAVIOUR OF PRIMATES

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Part 1: Enrichment


Nongenetic Induction of Acquired Levels of Aggression

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This article proposes the empirical hypothesis, supported by a review of primarily primate laboratory research, that there is some direct mechanism for the nongenetic transmission of acquired levels of aggression from mother to offspring. When aggression levels of the mother are experimentally altered, the aggression levels experienced during maternal dependency over a wide range of conditions are positively related to subsequent aggression levels of offspring. This behavior cannot be attributed to simple genetic mechanisms of inheritance of aggressiveness and is in conflict with many learning-conditioning explanations. This mechanism, rather than leading to the production of a fearful and nonaggressive individual when that individual is subjected to high levels of maternal abuse, results in the production of an individual with aggression levels related to those experienced during the period of maternal dependency. It would be advantageous to possess a mechanism whereby an infant would quite automatically copy or internalize behavioral characteristics or modifications shown by the mother.

With the demise of Lamarckism it has been assumed that early acquired adaptive behaviors can only be transmitted from parent to offspring through the vague mechanism of what has come to be termed early experience. Here behavior is transmitted either through observational learning, something very difficult to demonstrate under controlled conditions (Chamove, 1974a; Hall, 1963), or through some hypothesized mechanism whereby the behavior of some other individual has an effect on some behavior of an infant. The latter mechanism is often couched in terms like "peer inter-

action gives infants the opportunity to develop play skills." These categorizations exclude the indirect effects of an adult's selecting an environment in which certain behaviors are more likely to be learned (Galef, 1976), but are believed to include the majority of what is developed during early experience. Examples of the latter categorization are the various instrumental or social learning theories of aggression; other theories include the much criticized theory of catharsis (Quany, 1976) and frustration theories (reviewed in Johnson, 1972; Moyer, 1976).

However, it would seem to be advantageous for an infant to be genetically programed to adopt rapidly any (potentially adaptive) behaviors that have been developed in the mother through her experience. This premise is based on the assumption that since the mother is surviving, these behaviors are relatively successful. One simple mechanism whereby this could be effected would be a genetically based predisposition for the infant to copy certain behaviors of the mother. By copy I do not mean to observe and imitate soon after, but to copy in a way comparable with a camera and film that may later be used to produce a print.
One might expect, therefore, that mothers transmit their behavioral traits to their offspring during the period of infant dependency. And as it grows older the infant exhibits these behaviors toward other animals and, perhaps, even toward its own mother.¹

Social Aggression

In attempts to understand the differing aggressivity of young macaques, infant monkeys have been reared from birth in varying conditions that have incidentally subjected the infants to differing amounts of aggression from their rearing companions. These amounts have varied from normal levels, as would be found in wild-born monkeys, downward to none. Monkeys reared with others in such a way as to subject them to more aggression than normal have also been tested. As these studies span 15 years, the data between studies are not always comparable; but the data within studies are, and it is these data I discuss. I wish to concentrate on only one behavior, social aggression, because this behavior is relatively less affected by other behaviors, such as disturbance or withdrawal, than are most other behaviors and is therefore more easily studied. Self-aggression is not discussed here (Chamove & Harlow, 1970; Anderson & Chamove, in press). I use the term aggression to mean overt aggression, usually physical assault or threats of assault, which Blanchard & Blanchard (1977) refer to as alpha attack or offense and not defense. I use the term aggressiveness to mean a predisposition for aggressive behavior. This definition of aggressiveness includes both “preparedness to fight,” which Wilson (1975) feels should not be part of aggressiveness, and “the duration and intensity of the act in the face of ambiguous stimuli,” which some might interpret as a measure of persistence rather than aggressiveness. Lagerspetz (1969) found these two variables to be characteristic of mice bred for aggressiveness but independent of one another in a factor analysis. She termed them latency of attack and aggressiveness. Also, Chamove (1974b), factor analyzing the behavior of juvenile rhesus macaques, found different factor loadings on the nine measures of aggression depending on whether he used frequency or duration scores, although intercorrelations of frequency, duration, and modified frequency measures were high. Aggressiveness is measured operationally by some measure of the duration of aggression in some test situation, and the predisposition for aggression is inferred from the level of this observed behavior. The type of aggression measured is usually an attempt to ensure relative dominance and appears to fit none of the eight categories of aggression provided by Moyer (1976).

I also concentrate on monkeys reared by a single caretaker, given additional social experience with at least one other monkey, and tested by being in a situation of facing an unfamiliar peer or younger animal. I think the results from studies on nonhuman primate aggression suggest the hypothesis that there is some other direct mechanism for the induction of acquired levels of aggression from mother to offspring. This hypothesis would be supported by a positive correlation between the amount of aggression experienced by the infant during the normal period of infant caretaking and the amount of aggression shown by that infant in conditions when it was possible for it to be aggressive. As I know of no study designed to test this hypothesis directly, I review those studies that bear indirectly on it. This means that some of the differences reported may be accounted for using other mechanisms, such as genetic theories, but that no one theory except the one suggested here can account for all of the results. Some of the differences reported may not be statistically significant or may not have even been tested for significance, but the trend is consistently in the predicted direction. The subjects used were rhesus macaques (Macaca mulatta) unless otherwise stated.

It seems that most studies of primate social development observe the effect of some general variable on specific behavior. For example, Arling (1972) wished to see the
effects on social development of being reared by an abnormal mother. He recorded the development of playful, aggressive behavior by the infants and recorded similar behavior by mothers who had been reared in isolation. The mothers showed high levels of aggression and low levels of affiliation toward the infants, and the infants were not very playful toward peers. He then inferred that the abnormal mothering or the low peer play led to those abnormalities later found in the social behavior of those infants in the second year of life, namely, high levels of aggressive behavior (Sackett, 1968). But it is rare that an attempt is made to make these inferences statistically explicit. Is there a correlation between maternal aggression and infant play or juvenile aggression, or between infant aggression and juvenile aggression? In fact, little research has been devoted to ontogenic issues in children's aggression (Hartup, 1974). Many of the subjects were reared by mothers, sometimes their biological mothers. In the studies described below the aggressiveness of the mothers was altered by experimental means, and therefore the innate level of aggressiveness of the mother could not have been a factor in producing the results. The results imply one-way causation, and although it is likely that the experimental manipulations altered the behavior of the infants, it is not likely that the behavior of the infants produced even a small proportion of the variance in maternal aggression reported during the first 3-6 months of life. Finally, the hypothesis posed herein is not intended to be the sole cause of aggression. Other factors lead to brief changes in the level of aggression: reduction of food or space (Southwick, 1967), hormonal changes (Joslyn, 1973; excellently reviewed by Brain, 1977), male suppression of violent behavior, and pain-induced aggression (Ulrich, 1965). One long-term influence is that of genetics (McClearn, 1974). Heritability indexes of aggressiveness of .49 in mice and .34 in domestic fowl have been reported (Fuller & Thompson, 1978; for data on humans, see Christiansen, 1974).

Nonhuman Primate Studies

Increased Aggression

Monkeys, because of the variance in their behavior and the susceptibility of that behavior to manipulation, have been the subjects of many of the experiments done to observe the effects of manipulating early experience on later behavior. Among the most aggressive socially reared monkeys are those reared by motherless mothers, females who were themselves reared in isolation. Less aggressive are normal wild-born mothers who have had at least one previous infant; they also groom their infants more and retrieve them less than do primiparous mothers. And least aggressive of mother-reared monkeys are wild-born mothers with their first infant. During the first and second month after birth, wild-born multiparous mothers punish their infants five times and twice as much, respectively, as do primiparous mothers (Mitchell, Ruppenthal, Raymond, & Harlow, 1966), the difference being especially marked in the category labeled bite. On the other hand, the firstborn infants of motherless mothers experience almost ten times as much maternal rejection and punishment during the first 30 days of postnatal life and twice as much in the next 30 days as do infants of wild-born multiparous females. Within these groups, mothers of males threaten and bite their infants two or three times more often than do mothers of females (Mitchell & Brandt, 1970; see also, Suomi, 1978; Mitchell, 1979).

During the first 6 months of life, and while still with the mother, all the above infants showed levels of aggression of the order predicted by the hypothesis. Monkeys raised by multiparous mothers showed over half again as much aggression, specifically the clasp-pull-bite behavioral constellation, toward other infants as did firstborn infants from wild-born mothers. The males were more aggressive than the females, although infants reared with no parental contact have shown comparable male-female differences (Chamove, Harlow, & Mitchell, 1967). Mitchell (1969) concluded that the fact that rhesus mothers punish their
male infants earlier and more often than their female infants may promote male assertiveness. He did not suggest a mechanism by which this might be accomplished.

Levels of aggression emerged as predicted after Sackett (1968) separated monkeys from their mothers and housed them in peer groups. The wild-born, mother-reared infants aggressed against unfamiliar peer stimulus animals twice as much as did isolates reared in wire cages and receiving no aggression in infancy. But the former were surpassed almost threefold by the very aggressive monkeys reared by motherless mothers. Arling (1972) reported three types of motherless mothers: active inadequate, passive inadequate, and adequate. He compared infants reared by the highly aggressive active inadequate with those reared by the less aggressive feral mother and by the least aggressive, adequate motherless mother by observing infants reared with their mother only for the first 8 months of life. The level of aggressiveness of the latter infants at 9 months of age was of the same order as that of the above infants. In addition, infants reared by the active inadequate were more aggressive than infants reared by the passive inadequate. Prepubescent, later-born mother-reared monkeys showed three times the hostility of firstborn mother-reared monkeys (Mitchell et al., 1966).

Mitchell, Arling, and Möller (1967) selected 32 juveniles of about 2 years of age and tested them with an aggressive adult and a young infant monkey after the subjects had been separated from their mothers for an average of 20 months. Most had been reared by normal wild-born mothers. After the investigators looked at the amount of punishment their mothers directed toward them during the first 3 months of life, the group was divided in half into a high-punished and low-punished group. The high-punished group threatened the stimulus monkeys over twice as often and bit them eight times as much as the animals who had experienced less maternal punishment during the first three months of life, supporting the present hypothesis.

In a study designed to assess the effects of inconsistent mothering, but one that also inadvertently subjected infants to above-normal levels of aggression, Griffin (1967; discussed in Möller, Harlow, & Mitchell, 1968) rotated the infants of wild-born mothers among four different females, changing from one mother to another every other week. These infants were often rejected and bitten when introduced to the new mothers. One of his control groups, the separation control group, consisted of infants separated fortnightly, but without the rotation, and then returned to the same mother. This separation experience seemed to make these mothers less punitive toward their infants than those mothers in the other control group, which involved no separation or rotation. Again, the aggressiveness of the infants was of the expected order, although none of the mothers reared their own infants. Aggression was almost nonexistent at the age of 19 months in the separation control monkeys, intermediate in the non-separated controls, and over twice as frequent in the rotated-mother groups. This difference was still present when the subjects were retested at 3 years of age (Sackett, 1968).

A study by Castell and Wilson (1971) offers some further support for my hypothesis. Using pig-tailed infants (Macaca nemestrina) reared only with their mothers, that is, mother-only rearing, reduction of the cage sizes was found to double the levels of infant-directed maternal aggressiveness (see Chamove, 1973b, and Southwick, 1967, for effects of cage size on peer-directed aggression in monkeys). The three infants reared in the small cages with the aggressive mothers were ranked 1, 2, and 4 when finally grouped with the two infants reared in large cages. That they were dominant suggests they were more aggressive, everything else being equal, which offers some support for the hypothesis.

Another study (Wolfheim, Jensen, & Bobbitt, 1970) offers only the most indirect support for the hypothesis. Two groups of mother–infant pairs were reared—one group in an impoverished environment and one in a much more complex environment of the same size. The infants in the impoverished group spent more time in contact
with the mother and actually played on her. If one infers from this that she punished her infant less, although there was no report of this behavior category, then this result may have influenced the reported lower levels of mother-directed aggression in this impoverished group when compared with the complex group.

Alexander (1967) found the same effects when he reared three groups of rhesus monkeys by restricting peer social interaction but allowing maternal social experience: (a) mother only for 8 months, (b) mother only for 4 months, and (c) a control group given peer contact and contact with the mother from birth. The amount of punishment received by the infants in the first and second 4 months of life was least in the third and greatest in the first group, a finding confirmed by Rosevear (1975) and Hinde and Spencer-Booth (1967) for rhesus monkeys and by Kaplan (1972) for squirrel monkeys. When tested as juveniles in confrontation with strange peers, aggression against these peer stimulus animals was greatest in the first group, intermediate in the second, and least in the last, the control group. Retesting by Mitchell (1970) confirmed that these differences persisted up to 6 years of age.

Young and Hawkins (1979) compared the behavior of infant baboons reared either in unstable aggressive groups composed only of mothers with their infants or in stable harem groups with males, mothers, and infants. The infants from the stable harem groups showed significantly more contact and noncontact aggression than the infants from the unstable groups.

Reduced Aggression

To produce a situation of levels of aggression reduced from those found in normal mothering, the following three rearing conditions were used after separation of the infants from their mothers at birth (Chamove, Rosenblum, & Harlow, 1973): One group of monkeys was given an inanimate surrogate mother made of cloth and was allowed 1 hour of daily social interaction with another surrogate-reared infant; in another group each monkey was continuously housed with another infant; and in a third group each monkey lived with three other infants. The surrogate mother, of course, never punished the infant, for it was a mother with "infinite patience," but the other surrogate-reared infants, with which the experimental group of surrogate-reared infants were allowed to play, showed some aggression during their 1-hour daily encounters.

Although one could argue that the most salient figure in the infant's environment was the inanimate surrogate and that most of the attachment of the infant was toward that surrogate, it would seem that in a situation in which the infant is exposed to the aggression of other infants, the hypothesized mechanism for the induction of aggression would respond to the levels of aggression found coming from the infant's peers. In the dyadic, "two-together-together" (two monkeys reared together) group there was actually less aggression than in the surrogate group. The former animals were called together-together because when disturbed they would cling together. Aggression in this group usually occurred when one of these infants tried to disengage itself from the affectionate clutches of the other. In the four-together-together situation, aggression was rarely seen, perhaps because there were always alternative bodies to cling to. In this situation the behaviors that are normally directed toward the mother are directed instead toward the peer.

The three groups were compared with five other groups of four infants reared by normal wild-born mothers, that is, infants that had experienced a normal amount of aggression, but which exceeded by several times that experienced by the three experimental groups (Chamove et al., 1973). Although the monkeys were only tested with familiar like-reared peers, the ordering of aggression during the first 6 months was as predicted by the hypothesis. The four-together-together subjects, which received the least aggression in infancy, showed the least peer-directed aggression, the two-together-together subjects showed about twice as much, the surrogate-reared infants
showed about four times as much as the dyadic group, and the mother-reared group, which received the most aggression in infancy, showed over twice as much as the surrogate-reared monkeys.

As a sequel (Chamove, 1973a) to the initial together-together study, I attempted to separate the unique components of two-together-together rearing, which consists of rearing an infant (a) always with another infant, (b) with that infant being the same infant, and (c) with that infant being a single infant. The reason for this separation was an interest in the high level of clinging and low level of playing exhibited by the togethertogether monkeys. So four groups of six monkeys each were arranged: Six always lived in the same pairs, the two-together-together monkeys; six lived in pairs that were separated on alternate weeks, the together-apart group; six lived in pairs that changed in composition weekly, the changing-together group; and six lived in a group together, the six-together-together group. The amount of aggression seen in the homecage rearing situation during the first year of life was highly related to that found after 2 years of age, when the subjects were tested with unfamiliar stimulus animals. During rearing the changing-together infants were twice as aggressive as the almost totally nonaggressive six-together-together animals, whereas the together-apart infants were almost three times and the two-together-together dyads over three times as aggressive as the six-together-together group.

When tested individually at 2 years of age with juvenile and adult stimulus animals, the six-together-together group was slightly above the changing-together group in aggression, a slight reversal of the predicted order. This result was due to the fact that the six-together-together group was more aggressive toward the adult stimulus animals than the changing-together group was toward the juvenile stimulus animals. I cannot explain the differential responsiveness to adults and juveniles. As predicted, however, the two-together-together group was four times as aggressive as the six-together-together group, and the together-apart group was intermediate in aggression.

Deets (1973) compared the behavior of mothers rearing a single infant with that of those rearing two infants, neither infant being the mother's biological offspring. The twin rearing led to only half the infant-directed aggression by the mother during the first 3 months in comparison with the singleton rearing condition, and the singleton infants were more aggressive than the twins at 7 months and 2.3 years of age.

In another study (Chamove & Delizio, Note 1) designed to manipulate dominance, 24 infant monkeys were assigned to one of three groups: the dominant group, given all of their social experience from infancy with two much younger monkeys; the intermediate group, always with one older and one younger monkey; or a subordinate group, always with two older monkeys. The dominant subjects were the most aggressive and were never the object of aggression, but were the object of most of the play behavior; interestingly, the intermediate animals received most of the aggression and an intermediate amount of play; subordinate monkeys were the least playful and received an intermediate amount of aggression. Measures of aggression, obtained when the monkeys were later tested with infant and juvenile stimulus animals, supported the hypothesis. The intermediate group was the most aggressive, the subordinate group less aggressive, and the dominant monkeys the least aggressive toward the stimulus animals.

When dominance is not manipulated experimentally and individuals in 2-year-old groups of peer-raised animals are merely selected for study on the basis of their spontaneously emerged dominant and subordinate status, animals occupying different ranks behave differently (Altmann, 1969; Candland & Leshner, 1974). This example is different from all others cited herein in that information on the early experience of these monkeys relevant to the hypothesis is not available; therefore, the results do not bear directly on the present hypothesis, but they do influence how one must look at other dominance data and so are briefly mentioned here. What is known concerning these spontaneously emergent dominant and subordinate monkeys is their behavior at 2 years of age, prior to and
subsequent to testing (Chamove & Bowman, 1978). In addition, one might expect the behaviors seen in different dominance ranks to be at least as characteristic of the individuals occupying those ranks as of the ranks themselves. Whether a dominant monkey is aggressive or not will depend on its personality; whether a monkey is dominant or not, however, will depend on its persistence, its use of strategies, and its alliances.

Dominance rank and frequency of aggressive outbursts are not highly correlated (Chamove & Bowman, 1976, 1978). In such groups, when hostility is accentuated by limiting a resource, that is, in a water bottle competition test (described in Boelkins, 1967; Chamove & Bowman, 1978; Christopher, 1972), the most aggression is shown by dominants, the least by subordinates: when dominants, intermediates, or subordinates are placed together in a single group, aggression shows the same pattern as in the competition test—most for dominants and least for subordinates (Chamove, Note 2). These results suggest that once dominance is determined, the behavior patterns are maintained and are not constantly modified by resulting changes in experience.

Also of relevance to the hypothesis is another study just completed (see Chamove, 1978a), from which results are only partly analyzed. Four groups of stump-tailed macaques (*Macaca arctoides*) were used. The subjects comprising the mother–peer group were reared by their mothers in continuous contact with their own and other mothers and peers. All other groups were composed of infants that were separated from their mothers soon after birth and housed so they could not see other monkeys. These were all given social experience for at least 1 hour per day. The infants comprising the adult–peer group were put with wild-born adult females who had previously reared infants of their own, so these infants had contact with both adults and peers for 1 hour daily. The infants in the light–peer group were put with peers only. And the infants in the dark–peer group were put with peers in the dark so that they never saw other monkeys; for the remaining 23 hours they were in their own cages in normal lighting.

When viewed with a special television camera sensitive to infrared light, the dark–peer group showed surprisingly normal behavior, except that they were never seen to show any aggression. Most of their other behaviors were similar to those of the light–peer group. The light–peer group showed the usual, commonly reported low levels of aggression. The mother–peer group infants were exposed to higher levels of aggression, that is, to so-called normal levels. But the adult–peer group infants were the objects of the most aggression. It appeared that their playful and/or disturbance behaviors irritated the adults, and in the absence of a protective mother, they were threatened, chased, and bitten more than were the other groups.

The experimental conditions were terminated after a year, and all animals were tested alone with peer stimulus animals with which they were unfamiliar. They were then housed in groups of four with other familiar animals from their rearing condition. After this they were retested with stimulus animals and then in round-robin pairings. The results of all of these tests confirmed the hypothesis, with the monkeys ordered in aggressiveness from highest to lowest as follows: adult–peer, mother–peer, light–peer, and dark–peer.

Another experiment (Chamove, 1978b), designed to evaluate different types of "therapy" administered to socially abnormal monkeys, is also relevant to the hypothesis. A group of 9-month-old rhesus monkeys reared alone in bare-wire cages and a group of 3-month-old similarly reared monkeys were each subdivided into three groups. Members of one subgroup from each of the two groups were paired with 3-month-old infants daily for 20 weeks; members of another subgroup from each group were paired with 9-month-old partial social isolates; and members of the third subgroup from each group were paired with 9-month-old socially experienced but nonaggressive monkeys. Those paired with infants were exposed to the least aggression of the three, those paired with partial isolates were exposed to the most, and those paired with socially sophisticated partners were exposed to an intermediate amount.

When the monkeys were tested with others
from their own treatment condition, the following results, again supporting the hypothesis, occurred. Infants that had been paired with infants were the most pacific, whereas infants that had been paired with isolates showed almost one and one-half times as much aggression as the former infants. The other infant group was intermediate. The isolates showed the same pattern. Infant-paired isolates were the most pacific. Almost twice as much aggression was recorded from isolates paired with socially sophisticated peers. And the highest levels of aggression, almost three times that of the former group, were seen in those isolates paired with other isolates. Play behavior showed a similar pattern. Whereas infants were the most playful and isolates the least playful, the levels of play that the subgroups exhibited paralleled the levels of play shown by their partners toward them.

An instrumental model of aggression (Hutchinson, 1973) that assumed that an infant would positively reinforce aggression by withdrawal and fearful behavior and that an experienced monkey would punish aggression by being even more effectively aggressive in return predicted higher levels of aggression in monkeys paired with infants than in those paired with experienced and socially sophisticated animals. The reverse was found: Infants or isolates or even experienced monkeys paired with infants became less aggressive than did those paired with experienced monkeys or with isolates. The aggression expressed cannot be accounted for in terms of a history of its having been rewarded here through simple, direct reward learning.

Finally, Macaca irus are reported to be more aggressive toward infants than are Erythrolecebus patas monkeys (Seay, Schlottmann, & Thorne, 1970), and irus infants are also more aggressive than are patas infants (Seay, Schlottmann, & Gandolfo, 1972).

Statistical Validation

In an attempt to validate my hypothesis statistically, I looked at two sets of data. The first is a correlation coefficient matrix (reported by Mitchell, 1968) of 38 behaviors of 32 mother–infant pairs during the first 6 months of the infants’ life. Although the infants were able to interact with other infants, the behaviors reported by Mitchell were only those between mother and infant. Although the hypothesis suggests that maternally instigated infant-directed aggression will subsequently be expressed in peer-directed aggression by the infant, an extension of this idea would predict that perhaps some of this infant aggressiveness will be seen in mother-directed aggression by the infant. If one looks at the four maternal hostility categories—reject, threat, aggressive, and clasp-pull-bite—one sees that three of these maternal behaviors correlate significantly with the only infant hostility category reported, that is, clasp-pull-bite: .40 (p < .05), .74 (p < .01), -.11, and .36 (p < .05), respectively.

I continued analysis of these data using a factor analysis according to the method described in detail elsewhere (Chamove, Eysenck, & Harlow, 1972). Mitchell’s (1968) published intercorrelations were subjected to a principal-components analysis rotated to oblique simple structure. Three factors with eigenvalues above unity were extracted (see Table 1). Factor 1 was found to correlate with Factor 2 and Factor 3 (rs = .23 and .73, respectively), whereas Factor 2 correlated with Factor 3 (r = .28). Factor 1, which I have labeled infant assertive, supports my hypothesis. It suggests that aggressive infants, that is, infants that clasp-pull-bite their mothers, have mothers that threaten, reject, and clasp-pull-bite them but that do not treat them aggressively. This rather more violent behavior is reserved for Factor 2, which I have labeled maternal accept/reject, and suggests a less positive relationship between mother and infant at its negative extreme.

It should be noted that the second-order factors are 10 in number, although I have no explanation for this. One factor similar to infant assertive is the one with the largest eigenvalue, and the primary factor loadings here are even greater than in the three higher order factors (see Table 1). It is also interesting that in 32 rhesus mothers there is no correlation between aggress and clasp-pull-bite (r = .00), a negative correlation
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between threat and aggress \((r = -.12)\), and a positive correlation between threat and clasp-pull-bite \((r = .50;\) Mitchell, 1968). Also of interest here is the finding of an assertiveness factor. This finding supports previous results factor analyzing the behavior of 91 (Chamove, 1974b) and 168 (Chamove et al., 1972) juvenile rhesus monkeys and a different technique, principal component analysis of subjective rankings, with 10 rhesus monkeys (Stevenson-Hinde & Zunz, 1978).

The second bit of data used to statistically validate the hypothesis was a composite Kendall rank correlation derived from the 13 studies described above, excluding the cross-species studies of Seay et al. (1970, 1972). I ranked the aggressiveness

<table>
<thead>
<tr>
<th>Table 1</th>
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<tr>
<td><strong>Loadings of 38 Behaviors by Mother (M) or Infant (I) on Three Factors</strong></td>
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<table>
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<tr>
<th>Source of behavior</th>
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<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
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<td>I</td>
<td>Approach</td>
<td>.90</td>
<td>.12</td>
<td>-15</td>
<td>.99</td>
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<td>Incidental contact</td>
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<td>-.12</td>
<td>-14</td>
<td>.89</td>
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<td>I</td>
<td>Clasp-pull-bite</td>
<td>.73</td>
<td>.04</td>
<td>-01</td>
<td>.95</td>
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<td>.38</td>
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<td>I</td>
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<td>-.09</td>
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<td>.58</td>
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<td>M</td>
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<td>-.07</td>
<td>.05</td>
<td>.81</td>
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<tr>
<td>I</td>
<td>Look at mother</td>
<td>.60</td>
<td>.08</td>
<td>.02</td>
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<td>.90</td>
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<td>.10</td>
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<td>Present</td>
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<td>.62</td>
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<td>.11</td>
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<tr>
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<td>Gross contact</td>
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<td></td>
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<td>Approach</td>
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<td>.54</td>
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</tr>
<tr>
<td>M</td>
<td>Silly grin</td>
<td>-.11</td>
<td>.43</td>
<td>-.13</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Look at infant</td>
<td>-.12</td>
<td>.34</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Aggress</td>
<td>-.30</td>
<td>.87</td>
<td>.12</td>
<td>-.14</td>
</tr>
<tr>
<td>M</td>
<td>Nonventral contact</td>
<td>-.25</td>
<td>.69</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Coo</td>
<td>-.45</td>
<td>-.06</td>
<td>-.07</td>
<td>-.15</td>
</tr>
<tr>
<td>M</td>
<td>Mount</td>
<td>-.28</td>
<td>.05</td>
<td>-.17</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Play</td>
<td>-.28</td>
<td>.05</td>
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<td></td>
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<tr>
<td>I</td>
<td>Ventral</td>
<td>-.25</td>
<td>-.72</td>
<td>.07</td>
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</tr>
<tr>
<td>I</td>
<td>Nipple</td>
<td>-.14</td>
<td>-.67</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Embrace</td>
<td>-.17</td>
<td>-.74</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Embrace</td>
<td>-.19</td>
<td>-.76</td>
<td>.04</td>
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<td>M</td>
<td>Groom</td>
<td>.10</td>
<td>-.57</td>
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<td>Restrain</td>
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<tr>
<td>M</td>
<td>Retrieve</td>
<td>-.01</td>
<td>.09</td>
<td>-.42</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Submit</td>
<td>-.13</td>
<td>.04</td>
<td>-.24</td>
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</tr>
<tr>
<td>M</td>
<td>Orally explore</td>
<td>-.09</td>
<td>.13</td>
<td>-.72</td>
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<tr>
<td>M</td>
<td>Manually explore</td>
<td>.09</td>
<td>-.06</td>
<td>.75</td>
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<tr>
<td>M</td>
<td>Convulsive jerk</td>
<td>-.04</td>
<td>-.03</td>
<td>.25</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Imitate</td>
<td>.19</td>
<td>-.22</td>
<td>-.05</td>
<td></td>
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<tr>
<td>M</td>
<td>Submit</td>
<td>.06</td>
<td>-.08</td>
<td>.10</td>
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a These are loadings of one factor of second-order rank (see text).
of the animate attachment figure and the aggressiveness of the infant, choosing, where possible, behaviors shown when the monkeys were later tested with peers over which dominance was possible and when they were in the absence of the mother. This ranking made use of the means of the attachment figures' scores and the means of the infants' scores for each of the 46 groups making up the 13 studies. A close relationship was found ($r = .96$), suggesting that the level of aggression expressed by the most prominent attachment figure of a young monkey's social associates is positively related to the later aggressiveness of the infant toward its peers.

Some primate field workers have made similar suggestions. Imanishi (1961/1965) suggested that infant males may assume both their correct (sic) sex role and their correct dominance role by personal absorption of the personality of a specific adult male, that is, by identification in the Freudian sense. Others have felt that observational learning, for example, by the infant of the mother's behavior toward other group members, is more important than what they term the conditioning effects of the mother's behavior (e.g., Nagel & Kummer, 1974).

Nonprimate Studies

A search of the rodent literature was unsuccessful in revealing studies directly bearing on my hypothesis. The only study approaching relevance was by Kahn (1951); this study was partially replicated by Cairns (1973). Kahn used rats past the age of weaning and therefore at an age when one might expect different mechanisms from those suggested in this article as influencing the developing juvenile. He found that although a single severe defeat made a mouse temporarily more aggressive, multiple severe defeats led to reduced aggression in survivors that were later tested with a passive "danger" mouse (see also, Motshagen & Slange, 1975). Work by Ryan and Wehmer (1975) suggests that aggression in the mouse may be more complex. They found that mice from large litters had lower weights but higher emotionality levels than did mice from small litters. The former were more aggressive during group living, and they were more aggressive upon initial, but less aggressive upon subsequent, encounters with strange mice.

Similarly, prior exposure to inescapable shock reduces the frequency of shock-induced fighting in adult rats, whereas escapable shock does not lead to similar reductions (Maier, Anderson, & Lieberman, 1972).

Uyeno (1960) cross-fostered rats bred from parents selected for dominance and subordinance. Surprisingly, genetically dominant rats reared by genetically dominant mothers became relatively subordinate compared with dominants reared by subordinate mothers. Genetic subordinates were not differentially influenced by maternal type. The behaviors the mothers exhibited during rearing were not reported. Lagerspetz (1969) cross-fostered mice pups from a strain bred for aggressiveness. He found little differential effects of mothering on aggressiveness of the pups. Most of the other studies have used subjects even older than weaning age, often in competition for food (Frederickson, Fink, & Parker, 1955; Scott & Frederickson, 1951).

Frederickson and colleagues tested two strains of mice, C57Bl/6 and BALB/C, at a very young age (30 days) in food competition and found no effect of the aggressive level of the rearing mother. Southwick (1968, 1970), using strains more divergent in aggressivity than those of the above study (A/J and CFW), found an increase in aggressive behavior of between 50% and 100% in the passive strain cross-fostered by the aggressive CFW, when compared with appropriate controls. Neither study reported maternal behaviors toward the infant. McCarty and Southwick (1979) recently completed a similar study. They found that rearing by nonaggressive white-footed mice foster parents led to reduced aggression in normally aggressive southern grasshopper mice towards laboratory mice, although fostered white-footed mice showed no systematic changes in comparison with controls. There is evidence that the mothers showed species-typical aggressive patterns toward these pups, since only 45% of pups cross-fostered to the aggressive grasshopper.
mice survived, whereas 77% fostered to the pacific white-foot mice survived.

Brain (1977) reviews the work on early handling and subsequent aggression. Most of the few studies addressing that question show increased aggression or dominance. Denenberg (1970) ties together the above two areas of research. He cross-fostered C57BL/105 mice to either aggressive mice or nonaggressive rats. There was a 44% reduction in the aggressiveness of the latter group. These nonaggressive mice also showed considerably less of a corticosterone response to a novel environment. 20 μg% less. Simply having a rat aunt was as good as a rat mother in reducing aggression, but not quite as good in reducing the adrenocortical responsiveness to novelty. The more the rat aunt interacted with the mouse pup, the greater the effect. Denenberg and Rosenberg (1967) showed that early handling of rat pups affects several behaviors of the grand- pups of the handled animals.

Another possible causal mechanism involves the sex hormones. If, as suggested by Thiessen (1976, pg. 75), aggression is organized by the early influences of androgens, and the hypothalamus is most sensitive to gonadal steroids when these levels are low, then the effects of early stressors on gonadal secretions might lead to long-term central nervous changes relevant to aggression levels. If this is so, one might expect correlations between androgen levels and aggressiveness level in social isolation and perhaps also in social groupings.

Human Studies

A brief look at the ethnological literature on human societies, despite all its caveats, gives some support to the hypothesis. Those cultures reputed to be at the two extremes of aggressiveness are correspondingly extreme in their use of physical punishment during child rearing. The aggressive Yanomamo (Chagnon, 1974) and Ik (Turnbull, 1972) use a lot of physical punishment during this child-rearing period: the nonviolent Semai (Dentan, 1968) and Cheyenne (Hoebel, 1966) are reported to use none (see also, Parke, 1978).

Kagan and Moss (1962), in their study of the effects of child-rearing practices on the behavior of individuals in Western culture, concluded that maternal restrictiveness during ages three to ten was the most consistent correlate of aggressive behavior in adult men and women. Maternal hostility was the best correlate of aggression to peers during childhood. (p. 224)

Sears, Maccoby, and Levin (1957), among others (Bandura & Walters, 1959; W. C. Becker, 1964; Eron, Walder, & Lefkowitz, 1971; McCord, McCord & Howard, 1970), concluded that the pattern of child rearing that produces the most aggressive children is one in which the parent punishes the child using physical aggression or threats of physical aggression. Reviews of the published literature on agonistic behavior concur with the suggestion that at least one antecedent of aggressive behavior is past exposure to physical punishment (Feshbach, 1964; Johnson, 1972; Parke, 1978; see also, Bandura, 1973; Carrol, 1977; Lefkowitz, Huesmann, & Eron, 1978). Neither the mechanism for this connection nor the degree of association is specified. Nevertheless, recent reviews conclude that the social milieu is the most important determinant of human aggressive behavior (e.g., Baron, 1977), and the levels of aggression may be determined and stabilized by the age of 3 years (Oliveus, 1979). There was no evidence in the primate data reviewed above that deprivation of physical affection was an important factor in the ontogenesis of violent behavior, as was suggested by Prescott (1977) in a review of 49 human cultures.

Punishment

Extrapolation from some of the existing studies manipulating punishment suggests that early punishment may lead to two different effects: aggression or withdrawal. Punishment of shock-induced aggression in squirrel monkeys leads either to self-directed aggression or to a slumped posture suggesting helplessness (Ulrich, Wolfe, & Dulaney, 1969; reviewed in Johnson, 1972, and briefly in Moyer, 1976). Whether early punishment leads to later aggression is yet an open question, however.
In my research on manipulation of dominance rank I have noticed a similar finding. When eight monkeys, four rhesus and four stump-tailed macaques, were made subordinate as described earlier (by placing them with older animals) and when all of their early social experience was in a subordinate position, two types of monkeys were soon apparent: One was the type of animal we (Chamove & Delizio. Note 1) termed the true subordinate, usually an emotional animal, but one that rarely or never challenged its position of subordination: the other type of monkey was one that never seemed to accept its status, that is, showed rebellion in certain circumstances. In the latter case we had to be careful in the daily socialization procedure, for if our dominant subjects did not immediately assert their dominance, the rebellious subordinates would sometimes threaten them. Also, when first grouping them with new dominants, we had to be very careful to arrange factors such as territory and adaptation so that the subordinate did not challenge the dominant. The latter correlate we found of this phenomenon was emotionality: The true subordinate was more emotional. We measured emotionality before any social experience had taken place: the measures included tests such as responses to novel environments and novel objects. With the rebellious subordinate monkeys, repeated defeats did not lead to withdrawal, whereas in the true subordinate they did. This result suggests that some individuals are insulated against the development of helplessness, or at least against the mild defeats that occurred in the experiment. Relatively mild defeats may be like Kahn’s (1951) single severe defeat, leading to recovery and hyperaggression, whereas repeated severe defeats lead to increased emotionality and withdrawal.

Physiological Basis

"There is no evidence of any mechanism . . . that could act as a spontaneous internal drive for fighting" (Scott, 1967, p. 47). Nevertheless, a possible physiological substrate of this dual response to attack is suggested in an experiment by Harwood and Vowles (1967: see also, Andy & Stephan, 1974). They found that whether electrical stimulation of a site in the anterior hypothalamus of the ringdove led to aggression or fear toward a toy spider predator was determined by the emotional state of the subject at the onset of stimulation. If the dove was afraid, the stimulation led to exaggerated withdrawal; if the bird was aggressive, the stimulation induced a more intense attack. Although they did not report intraspecific behavior, probably preferring the control possible with a toy, one can see how such a mechanism could be adaptive both inter- and intraspecifically. As a short-term mechanism, the individual could react more rapidly and strongly should a predator remain nearby following exposure to the predator. As a long-term mechanism, an individual could react more rapidly to varying social stimuli within a group. When near a dominant animal, for example, the subject could be "primed" so that any sudden movement of the dominant would lead to more rapid withdrawal than if the subject had to reclassify the sudden movement after it had begun.

Another possible mechanism might be the following. Early stress may lead to a change in the balance of neuropeptides located in the pituitary and thereby change the sensitivity of pituitary-related mechanisms, leading to opiate-like changes in response to stimuli. There is some support for such a mechanism. Enkephalin-containing neurons and opiate receptors are concentrated in portions of the brain that mediate pain perception and emotional behavior, and one receptor is localized in the pituitary gland (Snyder, 1978). If this mechanism truly exists, then one might predict changes in response to external stimuli and activity changes in early recipients of aggression or pain during early handling. Changes to the amygdaloid limbic circuit alter both aggressive behavior and activity patterns (Gloor, 1975: Karli, 1974; Thompson, 1969). Barbiturates change fearful cats into predatory cats, and alteration of the epileptic excitability of the amygdala of predatory cats by repeated electrical stimulation changes their behavior from aggressive attack to defense (Adamec, 1974). Adamec cited the above as support for the hypothesis that aggression is a result of a
redistributed sensitivity to external threat. This hypothesis is also supported by the finding that aggressive monkeys learn avoidance slower than do less aggressive monkeys (Levine, Gordon, & Rose, 1970). A similar reduction in response is found in the early-handling literature (Denenberg & Smith, 1963; Denenberg, 1970), suggesting an inverse relationship between emotionality and aggression (Matte & Tornow, 1978).

Other work with mice (Henry, Stevens, Axelrod, & Mueller, 1971) has shown that whereas early weaning and isolation reduce the enzyme required for the methylation of noradrenaline to adrenaline, housing so as to increase social conflict increases the level of this enzyme above that of normally reared mice. Exposure to aggression directly influences noradrenaline (Eleftheriou, 1971) and leads to a release of androgens (Mason, 1961, see also Anisman, 1978). Hofer (1974) suggested that all early experiences that entail decreased levels of stimulation lead to a tendency for later cardiac responses to stimulation to be decelerating; increases in early stimulation levels lead to a subsequent tendency for heart rate acceleration.

**Learning**

Wilson (1975) suggested the following:

> Unless some Lamarckist process is at work, individual acts of learning cannot be transmitted to offspring. If learning is a generalized process whereby each brain is stamped afresh by experience, the role of natural selection must be solely to keep the tabula rasa of the brain clean and malleable. To the degree that learning is paramount in the repertory of a species, behavior cannot evolve. . . . What evolves is the directness of learning—the relative ease with which certain associations are made and the acts are learned, and others bypassed even in the face of strong reinforcement. (p. 156).

Throughout this literature people often alternate between restricted and wide usages of the term learning without apparently realizing it, going from a set of well-defined conditioning paradigms to the assumption that any change resulting from external input is an example of learning. I am suggesting that more than the directness of learning has evolved. In infancy, aggression by x not only teaches the infant that x is aggressive and that the infant should withdraw (Fowler & Wischner, 1965), but it also triggers a mechanism that causes the infant to be aggressive, a mechanism that because it does not obey the laws of conditioning, does not appear to be learning in the sense Wilson (1975) means. The laws of conditioning suggest that if a subject is presented with an aversive stimulus, there are two effects: Some negative emotional effect like fear is connected with the salient stimuli in some classical conditioning sense, and avoidance responses are reinforced and learned in some operant sense.

The mechanism postulated here is also not modeling in that "children are furnished with vivid parental examples of how to influence the behavior of others" (Bandura, 1976, p. 207). Bandura (1976) has described four processes by which modeling activates aggression: (a) Copying the behavior of effective models often effective in reaching goals. (b) Copying aggressive behavior is anxiety reducing when done in situations in which prior aggression has been observed. (c) Observing aggressive behavior is emotionally arousing, which often facilitates aggression. (d) Observing aggression has stimulus-enhancing effects.

Learning through modeling is quite different from the mechanism proposed herein. Modeling has a substantial cognitive component: modeling focuses on behavior of the individual at an age when aggression is physically possible; modeling stresses at least situations in which the behavior modeled occurs soon after the demonstration, and modeling focuses on situations in which the subject is not also the object of the aggression. Certainly my mechanism would not apply to processes a, b, or d above: The infant has no opportunity to learn from being bitten by its mother that aggression achieves goals; it is difficult to imagine how infants can learn that aggression is anxiety reducing in situations comparable with those in which they received aggression: it is difficult to see how aggression from a mother could make a mother more salient, although it could of course draw attention to aggressive behaviors. Process c appears reasonable, but hardly accounts for the present findings.

These results cannot easily be explained...
by recourse to direct operant conditioning principles. But these principles do explain how punishment of the subject later leads to increased levels of aggression in the subject. No reinforcement is contingent on the performance of an operant (Motshagen & Slangen, 1975). Further, the results cannot easily be explained using principles of classical conditioning. These principles could explain how attack or punishment of the subjects leads to the conditioning of an emotional response to the stimulus of the caretaker or to certain behaviors of the caretaker. But they would not explain how the emotional response subsequently leads to aggression toward other animals. One could posit that an aggressive mother generates frustration but also generates inhibition, say, through direct punishment of aggression in the infant. The frustration may be generalized to other monkeys later and the inhibition not so generalized. This convoluted explanation is not as simple as the one proposed herein. It may be that emotional conditioning is foremost in early development but that later on operant effects are most important.

Scott (1966, 1975) suggested that one developmental mechanism that could account for the absence of fighting between littermates is that of passive inhibition. He continued, postulating that the animals associate a particular situation with the absence of a particular kind of behavior. Such a suggestion would not account for the findings discussed here, for infants would be expected to associate fear, pain, withdrawal, and the absence of an aggressive response with social situations.

One area in which appropriate learning is impossible is that of social isolation. During isolation the individual receives no aggressive assault and yet may become very aggressive. Isolation leads to increased (Scott, 1966) or decreased (King, 1957) aggression in rats and mice and increased aggression in rhesus monkeys (Chamove, 1978a; Sackett, 1971) when these individuals have the opportunity to attack subordinates. The reverse effect has been reported in dogs (Scott, 1975). Certainly, macaques differ greatly in their responses to isolation. Tailed macaques were less affected by isolation than were rhesus macaques (Sackett, Holm, Ruppenthal, & Farhenbruch, 1976), and my replication (Chamove, Note 3) showed stump-tailed macaques to be even less affected. It is likely that isolation-induced aggression operates through mechanisms different (discussed in Rothballer, 1967) from those described in this article.

**Emotionality**

It is possible that the mechanism whereby maternal aggression is transmitted to the infant is similar to, or part of a mechanism for, the production of emotionality in the infant. Being the object of aggression early in life might be expected to lead to an increase in fear and perhaps to general emotionality and reactivity. Part of the factor Cattell and Kline (1977) labeled emotionality is annoyance, the presence of which could reasonably be expected to increase the probability of an individual’s being aggressive.

Estes (1944) posited that some of the effects of punishment are probably mediated by the emotional reaction aroused by the noxious stimulus. Also, stimulants have been found to enhance the effects of punishment, whereas tranquillizers have been found to attenuate these effects (Boe & Church, 1968).

But not all emotion-producing situations lead to increases in aggression. Rat pups rotated among mothers every day (Ottinger, Denenberg, & Stephens, 1963) and rhesus monkey infants separated every 2 weeks (Griffin, 1967) are more emotional, but are not more aggressive. Other related types of stress, when there is a stable mother–infant bond, do increase aggressive behaviors. After mother–infant separation and reunion, rhesus infants are hyperaggressive toward peers (Seay, 1966). Similarly, early handling in rats gives rise to more dominant rats when they are tested in repeated pairings (G. Becker & Gaudet, 1968).

Rats bred for low open-field emotionality were reported to be more aggressive than those bred for high emotionality (Hall & Klein, 1942). The aggressive strain of mice bred for differing levels of aggressiveness has been characterized as less emotional and
more active than the nonaggressive strain. Inflicting pain before weaning retarded the appearance of aggression in these hyper-aggressive animals (Lagerspetz, 1969). These aggression-emotionality discontinuities argue against a frustration-aggression interpretation of the data reviewed above.

Other types of early stress lead to reduced emotionality, for example, shock and handling (Denenberg, Ottinger, & Stephens, 1962; Denenberg & Smith, 1963). But early shock experience has two effects: These animals defecate most in their first exposure to the open field, but defecate less over subsequent exposures (see also, Ryan & Wehner, 1975, reported earlier). This suggests the possibility of early stress resulting in an initial emotional response to novel situations, which then leads to hyperaggression.

Bandura (1973) suggested that arousal facilitates aggression to the extent that aggression is a dominant response, and his suggestion is supported by other studies (e.g., Konecni, 1975). Early stress may lead to higher baseline levels of 17-hydroxy-corticosteroid levels, and squirrel monkeys with higher baseline levels are more aggressive and achieve higher dominance rank (Candland, et al., 1977).

Evolutionary Implications

Evolutionary implications favor the non-genetic inheritance of acquired behavioral characteristics. Such a nongenetically based mechanism would serve as a more rapid and more flexible alternative to genetic transmission of adaptive behaviors such as levels of aggression. If changes in a behavior, say, an increased level of aggression, are associated with success in survival, then the caretaker can rapidly alter the characteristic levels of behaviors in its offspring, provided the infant is designed in such a way as to allow this transfer of behavior potential. This ability to alter an infant's behavior would lead to even more rapid change than the microevolution suggested by Wilson (1971), which can lead to significant behavioral alternations in under 10 generations. The data reviewed have only shown that altering the aggressiveness of a mother leads to parallel changes in her infant. Whether this behavior change extends to the following generations has not been shown, but seems likely.

It is also possible to suggest a period when the effects discussed in this article would be most potent. I suggest that two factors might be important: the behavior of the mother and the behavior of close relatives. If these factors are important, then the most sensitive period would be when infants are first leaving their mothers for periods of interaction with other young animals (e.g., Einon & Morgan, 1977; King, 1957).

This transmission of acquired characteristics does not imply that aggression will increase with every generation, for the infant, when adult, will only approximate the aggressive level of its mother.

One of the implications from a provocative article by Christian (1970) is that dominant females should select mates to produce optimally dominant offspring. So, too, the hypothesis I am proposing implies that if some level of aggression is adaptive, then animals with this level of aggressiveness would prefer others with similar levels of aggression for mating partners. It has been suggested that there are genes favoring such homogamy (Wilson, 1971). There is some indirect evidence that monkeys with abnormally high levels of aggression prefer to be with others with comparable aggression levels (Chamove & Harlow, 1975; Sackett, 1968) and direct evidence that dominant and number-two-ranked animals prefer the highest ranking animals available, whereas subordinates do not (Chamove, in press: Chamove & Delizio, Note 1). Through these mechanisms, the number of families in the population with optimal levels of aggressiveness should increase.

Furthermore, in those animals in which there are considerable sex differences in levels of aggression, it may be advantageous for there to be an early association between infant males and dominant, successful adult males, as has been reported in several primates (Mitchell, 1969; Chamove & Delizio, Note 1).

This article has attempted to marshall evi-
dence supporting the empirical hypothesis that being the object of aggression early in life leads to increased aggression later in life. In each of the studies cited, there are confounding variables. But taken together, and including studies in which such transmission may have gone wrong, the findings mostly support the hypothesis.

An attempt has been made to discuss mechanisms through which transmission of acquired behaviors between mother and infant might operate. The most profitable mechanism appears to be the following. A young infant that has developed an attachment to its caretaker or peers is subjected to aggression or pain from these attachment figures. This is not aggression that is the result of aggression begun by the subject in some competitive situation (Rasa, 1976); rather, it is pain that leads to a conditioned emotional reaction of fear or perhaps conflict (Hutchinson, 1973). The adjustment of the infant’s aggressiveness does not simply reflect the individual’s experiences with reward or punishment contingent on aggression. It reflects more the ambience of the infant-rearing situation than the level of aggressiveness of blood relatives.

It may be that the copying mechanism posited here exists for other classes of behavior (see Chamove, Note 4, for an example of play). Indeed, many of the advantages attributed to the transmission of aggression levels would hold for these too, which would suggest that the mechanism involved might be more direct than the one suggested above. Infants may directly adopt levels of behavior equal or parallel to those of significant individuals in early life.

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ASSESSING THE WELFARE OF CAPTIVE PRIMATES — A CRITIQUE

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Recently there has been increased research interest in improving the welfare of captive animals, but there has been less interest in the rigorous operational definition of terms used when describing environmental improvement or enrichment, in evaluating the cost-effectiveness of enrichment, or in the development of theoretical models that guide research and integrate divergent studies. In this paper I will look at these three areas within the context of a review which are addressed by enrichment studies:

1. the problems produced by spatial restriction;
2. the goals of enrichment;
3. the evaluation of enrichment techniques.

The basic problem addressed by enrichment is that caged animals cannot or do not carry out their normal range of behaviour. One simple reason why captive animals are behaviourally restricted is simply the lack of space. There is evidence that small cage size is powerful enough to even inhibit the most robust measure of general well-being, namely that of reproduction (Doolittle et al 1976, Snowdon et al 1984). Many behaviour patterns are influenced by cage size and its related variable of crowding (Adams and Babladelis 1977, Archer 1979, Dantzer and Mormede 1983, Elton 1979, Kaplan 1986, Siegel 1980, Unshelm 1981) and group size (Chamove et al submitted, Goosen 1980, Millar et al 1988).

It is widely accepted that small cages increase the incidence of stereotyped movements and other non-locomotory abnormal behaviour patterns (Draper and Bernstein 1963, Paulk et al 1977). While it would usually be beneficial to increase cage size, one might expect activity stereotypies to disappear with a smaller increase in cage size than would be expected for exaggerated levels of aggression, for excess self-directed behaviour, and for behaviour caused by the absence of opportunities for foraging.

While there are many questions concerning environmental enrichment which have theoretical relevance, we can also ask, at a predominantly practical level, how we can improve enclosures.

Increasing psychological space

The problem with cage design is that it often does not make good use of existing space. One way of counteracting deficiencies in cage size is by increasing the psychological space of the cage. This idea can act as a unifying concept for many of the nonsocial techniques of enrichment.

To choose what aspects of the cage to change, one must understand what aspects of space are important to the animal in question. In other words, what do individuals do with additional space when they have it? They move through it, using it for various activities; they use the space to avoid other individuals and potential predators; they use it to look for food; et cetera.
There are several ways to increase psychological space. The simplest is the better use of existing space such as walls, floors, ceilings, and of course the cage interior.

Related to the problem of cage size is that of cage design. Bare, flat walls are easy to construct and to keep clean, but many animals cannot use flat walls. Often in zoos one sees primates housed in spacious cages, but in ones in which large open spaces go unused by the animals, and one problem of enrichment is how to use these valuable areas (Berkson et al 1963). To assess the effects of vegetation on callitrichid monkey behaviour, we grew climbing plants on three types of trellis fixed about 10 cm from smooth walls. Plants grew best on the small-mesh flexible plastic trellis, while monkeys spent most time on the large-mesh rigid wooden trellis. The presence of plants had no measurable effect on monkey behaviour, but the presence of the trellises did enrich the environment by allowing the monkeys to make better use of the available wall space.

The floor is one area of the cage which is often ill-designed or neglected. The floor and areas just above the floor are often kept clear for easy cleaning. In the large (27 m$^3$) enclosures, that we use for callitrichid monkeys, the floor makes up about 40 per cent of the total surface area that monkeys can use and as much as 66 per cent of the total horizontal surface area. In the wild these arboreal monkeys occasionally come to the ground to forage in the leaf litter or to cross open areas (Neyman 1980). In captivity they almost never visit the floor (1 per cent of the time) when it is bare but do so more frequently (15 per cent of the time) when the ground is covered with some leaf-like substrate.

The effect with terrestrial monkeys is even more dramatic. In a zoo, groups of ground living primates (Lemur catta, Cercopithecus aethiops, Macaca arctoides) spent about 15 per cent of the day on the floor when it was bare and dirtied with faeces and urine as normal. When the floor was covered with woodchips, the time spent on the floor increased by a factor of over 4 to over 70 per cent, a more appropriate use of the cage space (Chamove and Anderson 1979, Chamove et al 1982, Anderson and Chamove 1984) and one that closely approximates the proportion of horizontal surface area it occupies in those cages. Allowing domesticated animals the opportunity to forage has also led to reductions of abnormal behaviour and increases in activity (e.g. chickens — Bareham 1972, Hughes, 1976; pigs — Ekesbo 1981, Koornans 1981, Vestergaard 1981).

Yet another aspect of primate cage design which has been little researched is that of what goes into the interior of the cage. In laboratories this area is often empty or has a simple metal shelf, but some researchers have offered their macaques branches (Reinhardt 1987). With smaller monkeys the interior area may be filled with branches (Evans 1984). One field study suggests that callitrichid monkeys primarily use horizontal branches, and they move on vertical supports, mainly large tree trunks, only 4 per cent of the time (Garber and Sussman 1984). Nevertheless, many of the cages used for these monkeys have vertical branches hanging from them, perhaps because it is easy to hang and replace these vertical clumps. Measurements in our colony indicate that about 25 per cent of the branches are horizontal, 30 per cent oblique, and about 45 per cent vertical, with vertical branches usually thinner than horizontal ones. In the wild, thin vertical branches are used almost exclusively for access to food.
In the wild (Garber 1986) and in very large outdoor areas callitrichid monkeys spend most of their time (89 per cent, Chamove and Rohrhuber submitted) in dense networks of thin, flexible, non-woody tangles. These are not normally found in captive situations.

We are currently looking at branch use and branch preference in caged callitrichid monkeys (Chamove and Goldsborough submitted). From our preliminary results it is clear that these monkeys prefer a larger number of unevenly spaced branches; widely spaced supports are especially used by the more active juveniles and narrowly spaced ones by the less active adults. The monkeys primarily rest on large horizontal branches and move on large and medium sized horizontal branches, and rarely on any others.

Another way to better use of existing space is by sharing space. This can be done by mixing species, by making use of their characteristic use of different areas of an enclosure and the fact that they do not react to other species as they do their own (O’Neill, in press, Waser 1986). Ground living rodents eat fallen fruit in bird, bat, or primate exhibits in Edinburgh, Auckland, and Milwaukee Zoos. Mixing species also enables two enclosures to be combined giving more space for each species. The presence of other animals also increases the complexity of the environment, although this aspect of enrichment has only been touched upon (eg King and Norwood, in press). C. ceph us and C. nictitans are often (80 per cent) in polyspecific associations in the wild.

While animals can share the same space at the same time, they can also share space sequentially. Various methods of rotating animals have been used. If animals are very active for only 50 per cent of the day, they can be allocated an exercise area for half the day (Evans 1984). For certain scent-marking animals, this may make the area more interesting, for others more threatening or exciting (McGrew et al 1986). Longer-term rotation is also a possibility with different species. If enclosure design permits, moving a carnivore from its enclosure would allow a herbivore access to an area with long grass and saplings.

Dividing existing space is another technique of increasing psychological space (Erwin 1979, Erwin and Deni 1979, McKenzie et al 1986). This technique seems especially effective in reducing aggression, probably because visual input is so important for that behaviour. Dividers can be permanently in place or only used during periods of relatively high competition, like feeding time (Belzung and Anderson 1986, Chamove 1981). Aggressive competition in the presence of food, commonly offered in only one or two discrete locations, may be increased over non-feeding conflict by a factor of 10 (Anderson and Chamove 1984) with a concomitant 50 per cent increase in blood cortisol levels (Chamove and Bowman 1978), suggesting considerable stress.

The use of dividers can also require the animal to cover more distance when moving from one area to another. In an unpublished study, we divided rectangular rodent cages into a maze using strips of plastic. A number of developmental changes in the behaviour of the inhabitants resulted, especially an increase in activity and lower emotionality.

One can increase psychological space by encouraging animals to make more use of existing space and by changing the use of existing space. If individuals have to look for hidden food, then the space is changed in that it contains more
bits of information, has more potentially relevant choices, and more things can be done with the same space. The most effective technique to allow for foraging seems to be to scatter small items of a desirable food into the floor covering. Currently we are looking at other techniques for arboreal monkeys involving foraging in holes.

Individuals perform various other activities in large spaces. They learn the characteristics of their environment to enable them to find food, to threaten and avoid conspecifics, and to flee from predators. They approach novel stimuli even though these may be frightening, in order to learn about them. If one of the activities that go on in large complicated spaces is that of learning, then we can set tasks that require learning and see if they serve as enrichment. One way that we are experimenting with this is by making small, regular changes in the positions of branches in enclosures.

**Goals of enrichment**

Two complementary short-term aims of enrichment studies are to increase desirable behaviour and to reduce undesirable behaviour. It is widely accepted that activities such as coprophagy, regurgitation, hair-pulling, self-injury, or stereotyped movements are undesirable. Conversely exploration, play, affiliation and foraging are commonly considered desirable. Other behaviour may be classed as one or the other depending on its frequency: withdrawal or avoidance, reproductive behaviour, aggression, inactivity, displacement and feeding are desirable if moderate in frequency but usually undesirable if very frequent. For example, overeating, hyperaggression, and long periods of inactivity are believed to be indicative of poor health. Furthermore, an increase in desirable behaviour is usually believed to be associated with an improvement in physical or psychological health (Fox 1986).

There are at least three approaches in assessing desirability of behaviour: normality, observer/caretaker acceptability, and theoretical considerations. Probably the most common approach emphasizes normality: behaviour which approximates that found in the wild is held to be desirable. In other words, behaviour should fall within the range of values for the form and frequency seen in the wild (McGrew 1981). One problem of implementation is that the norms for many behaviour patterns vary, sometimes widely, with group size, habitat, season, and even from day to day with local weather conditions (Chapman 1985, Harrison 1983, Oates 1986, Richard 1985). If callitrichids rarely come to the ground in the wild, is it normal/desirable that they do so in captivity and so better use the available space? It is not normal for animals to operate mechanical puzzles in the wild, but is it desirable for them to do so and thereby keep active in captivity? Sign language in the great apes is another example illustrating that enrichment does not necessarily lead only to normal behaviour.

Another approach is to choose enrichment goals because they are identified from a theoretical rationale. This rationale might be to occupy the animals, to exercise them, or to increase more normal behaviours. An example might be a goal of inducing more exercise or calorie expenditure for animals based on their normal, free-ranging, or wild activity budgets (discussed in Chamove 1986), or
increasing problem solving opportunities, for example through burying food in woodchips, while taking into account feeding techniques in the wild.

Cages also function to limit the range of behaviour shown by an animal. Several lines of research have shown that increasing the range of foods eaten is more healthy (Kirkwood and Dow 1986), increasing the range of muscles used is healthier (Turnquist 1986), and increasing the range of stimuli to which one is exposed is healthier (eg Bollhorn 1980, Ekesbo 1981, Fox 1986, Gross 1972, Kendrick 1972, Renner and Rosenzweig 1987, Riley 1981) and less boring (Wemelsfelder 1985). Consequently, enrichment studies can try to increase the range of behaviour expressed (Ekesbo 1981) as well as increasing the range of stimulation available (Putten and Dammers 1976).

The most obvious of these behaviours, and considered by some to be the most important (Fraser 1980; Parker and Gibson 1979) is the opportunity to move and forage. Primates spend between 25 per cent and 90 per cent (mode = 55 per cent) of their day searching for and processing food (Clutton-Brock and Harvey 1977). Even in large semi-natural enclosures where monkeys are given high quality food in excess of their needs, mandrills still spend 45 per cent of the day foraging (Feistner personal communication February 1988). In cages this is dramatically reduced, to about 4 per cent in callitrichids (personal data), 5 per cent in chimpanzees and gorillas (Bloomstrand et al 1987, Gould and Bres 1986), and to 6 per cent in macaques (Anderson and Chamove 1984). Techniques to increase the search or processing time can increase this to around 10 per cent, 20 per cent and 30 per cent respectively.

In very simple enclosures it may also be impossible to perform certain behaviour at all, like dust bathing in chickens (Duncan 1977, Hughes 1976), wood gouging for gum in marmosets (McGrew et al 1986), and indeed foraging in most primates (Chamove 1981, Rosenblum and Smiley 1984).

Cages are believed to reduce the degree of control that individuals have. When rooms are visually divided, male macaques cannot control female aggression and aggression can increase (Erwin 1971, 1979). This change in behaviour after the imposition of dividers does not happen in stable callitrichid monkey groups (McKenzie et al 1986) or in stable macaque groups (Erwin et al 1976).

Reduction of control by being in cages is also exemplified by the effects of visitors on the behaviour of zoo animals (eg Chamove et al 1988, Hosey and Druck 1987, Glatston et al 1985). One can view zoo visitors as a stimulus in an otherwise barren environment; certainly many primates interact with visitors. An alternative to viewing visitors as a beneficial stimulus, supported by an increasing amount of evidence (Chamove et al 1988), is that visitors change the behaviour of monkeys in a way similar to that caused by other stressors. The data suggest that the greater the number of visitors, the more that behaviour is changed; noisy and active visitors cause more change; and visitors located at a level above monkeys cause more change than those at a lower level. This research suggests the importance of refuges for the animals to let them control access to and by visitors (Adams and Babladelis 1977, Maple 1979).

On a more conceptual level, many cage environments can be thought of as reducing the complexity and increasing the predictability of stimulation. In a
predator-free or predator-predictable environment (eg laboratory or zoo) or an environment where only one type of food is offered, decisions are more simple, alternatives fewer, stimuli more repetitive and predictable.

**Evaluation of the effectiveness of enrichment**

Assessment should be seen as crucial in studies of the effects of enrichment, since it answers the questions — Does the manipulation/enrichment do what it is designed to do? Are the effects reliable? And does it do it well enough to be worth the effort, that is, does the benefit exceed the overall cost?

The cost is most often viewed in terms of time or money, but can also be measured in terms of alternatives. If one form of enrichment is chosen, then other potential forms may have to be excluded. If a ball is chosen as the enrichment device (eg Renquist and Judge 1984), then this may be at the expense of other possible devices.

Just as cost can be seen from several aspects, so can benefit. To measure benefit one needs to decide on the importance of behaviour which is altered. Two extremes will illustrate the difficulty in such a decision. Certain behaviour may be considered important because it occurs frequently in the normal situation, such as foraging, locomotion, or huddling. King and Norwood (in press) consider the opportunity to leap to be important in squirrel monkeys, as over 40 per cent of their travel is accomplished by leaping. Other behaviour may be considered important precisely because it occurs infrequently in the normal situation. Dust bathing in fowl is an example (Dawkins 1976) or food-offering and sharing in tamarins (Feistner and Chamove 1986). Other behaviour is infrequent behaviour, which when used may actually lead to the reduction of common behaviour; allowing the use of tools enables capuchin monkeys to process certain nuts four times as rapidly as without tools (Visalberghi and Antinucci 1986) while the range of their behaviour increases.

As an example of these principles of assessment, between 1979 and 1986 a series of studies assessed the effects of covering the floor with a deep, absorbent litter in the large cages of ten different primate species (Chamove and Anderson 1979, Chamove et al 1982, Anderson and Chamove 1984, Chamove et al 1984, McKenzie et al 1986). The goal was to improve welfare, especially to increase activity and reduce abnormal and undesirable behaviour shown in some of these species.

The technique of enrichment used a 4 cm deep floor covering of woodchips with small items of prized food mixed into it. The choice of floor covering was not one of emulation — to copy nature, as this is impractical for almost all captive environments; rather the aim was simulation — to provide certain, possibly critical, components of the natural environment.

The effectiveness of the technique was measured over several months to determine costs and benefits and the stability of the behavioural changes. Technician workload was assessed, cage cleanliness and odour were evaluated, and changes in the animal’s behaviour was recorded. Bacterial vigour in the woodchips was also measured. Also a hypothesis was tested — that enrichment would be more effective when targeting behaviour more common to the animal in its natural setting. Therefore it was predicted that changing the opportunity
for an important and common behaviour pattern like foraging would lead to substantial changes; and that arboreal species would be less affected by providing a floor covering than would more terrestrial species, since the former are less likely to spend time foraging at ground level.

The results of these studies clearly showed the high cost-effectiveness of the floor covering in improving behaviour. The desired goals were achieved in the initial studies on stumptail macaques; self-injurious behaviour was reduced by more than half (see Anderson and Chamove 1981); aggression was reduced by a factor of 2 in adults and in juveniles by a factor of 10. Similar reductions occurred in all but one of the eight species subsequently studied and in which aggression was seen.

When the floor of the cage or enclosure was bare, macaques, of course, spent almost no time searching for food items on it. When the floor was covered with woodchips only, the animals spent about 5 per cent of their waking time searching through this floor covering. When grain was added to the woodchips, the monkeys' searching increased to almost 15 per cent of waking time, even when grain was also freely available elsewhere. When free grain was removed so that the only grain available had to be found and extracted from the woodchips, the monkeys spent over 30 per cent of their day foraging, which more closely resembles the behaviour of free-ranging macaques (Chamove and Anderson 1988, in press).

All of the primate species assessed have shown increased use of the floor area when it was covered with woodchips. We were surprised to find no support for our prediction that arboreal primes would benefit less from the floor covering: all groups showed increases in floor use. The increased time spent foraging was at the expense of other behaviour: aggression and abnormal behaviour were reduced, as was the amount of time spent inactive, and so too were play and affiliative behaviour but to a lesser extent.

The cost of this procedure was assessed in several ways. The time required for cleaning was reduced from 5 to 2 hours per week per enclosure when woodchips were used. The enclosures, especially the walls and windows, were judged to be cleaner, and they were rated as smelling less after four weeks with woodchips than after one day with a bare floor cleaned with water, detergent, and disinfectant. To assess the potential for the spread of disease when using the litter, samples of woodchips were removed periodically over eight weeks and either tested for the presence of bacteria, or inoculated with *Salmonella* bacteria and its survival time then measured. In agreement with tests using chickens (Turnbull and Snoyenbos 1973), the results clearly showed that the longer the litter was in use, the more inhibitory it was to bacterial survival.

In conclusion, this review supports the idea that enrichment is an attempt to ameliorate problems caused by containment, that the goals of enrichment are to alter behaviour so that it is within the range of the animals' normal behaviour, and that evaluation of the effectiveness of enrichment techniques is important. I am suggesting that the idea of increasing psychological space can act as a unifying concept for many of the techniques of enrichment. That is, many of the successful enrichment techniques act in a way similar to that of increasing physical space.
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Points raised in discussion

The question of whether the behaviour of primates in captivity should be natural was considered but it was pointed out that in nature some of the stimuli will be aversive or fear inducing. It was further discussed whether all stimulation in the laboratory should be non-aversive on the grounds that sometimes fear inducing or stressful stimuli might be beneficial. This approach was considered controversial as it was difficult to assess how far the situation should be allowed to go. In nature, a monkey may be torn apart by a predator and, clearly, any aversive stimuli in captivity must be of a mild character so that the natural situation could not be used as a model in this respect.

The point was made that, in some cases, primates may be kept in cages smaller than their flight distance. This would be stressful and it might be beneficial if monkeys could be provided with large outdoor runs provided that access was also available to heated indoor quarters. Methods of increasing foraging time were also discussed and two suggestions were made, firstly that food could be hidden in the cage and secondly that some food might be presented in a form which made it more difficult to eat, for example, providing marmosets with frozen bananas.
Impact of Feeding Practices on Growth and Behavior of Stump-Tailed Macaques
(Macaca arctoides)

Arnold S. Chamove and James R. Anderson

INTRODUCTION

Social relations between sympatric groups of primates, as well as between primates and nonprimates, often reflect competition between the animals over access to limited food supplies [Richard, 1985]. Within-group feeding competition occurs too, and it seems likely that pressures arising from such competition have played an important role in the evolution of primate social structures [Jolly, 1985].

Fluctuations in food supply can have considerable demographic consequences. For example, Altmann et al. [1985] reported that over a 15-year period during which there was high mortality of an important species of food tree, there was a 95% loss of a population of baboons (Papio cynocephalus). Dittus [1980] described a 13.5% decrease in a population of toque macaques (Macaca sinica) coinciding with a drought-related decrease in food supply. In these two cases mortality was particularly high among juveniles. Immature and adult female chacma baboons (Papio ursinus) also suffered high mortality as a consequence of a 5-month period of extreme food shortage [Hamilton, 1985]. In contrast to such population decreases following food shortages, one group of toque macaques with access to extra food (at a garbage dump) grew at an annual rate of 12.5% [Dittus, 1980]. Increased population growth during a period of supplementary feeding has also been reported in Japanese macaques (Macaca fuscata) [Mori, 1979; Sugiyama and Ohsawa, 1982].

Behavioral mechanisms influencing the distribution of food items among members of a group seem to be an important aspect of group processes, especially where attractive, spatially restricted food is concerned [e.g., Feistner and Chamove, 1986]. Interindividual spacing patterns play a role
here. Mori [1977] and Furuichi [1983] reported that adult Japanese macaques foraging for (abundant) natural foods tend to maintain interindividual distances of several meters, which reduces the likelihood of agonistic interactions. Aggression is more common when individuals converge on concentrated food sources, and it was reported to increase markedly when the monkeys crowded into a 14 × 9.5-m area to eat wheat given by humans [Mori, 1977]. In small cages, aggression owing to a single food source may increase by a factor of 4; the increase in the most dominant animals is even greater—aggression being about seven times greater than during baseline periods [Chamove and Bowman, 1978]. During such competition plasma cortisol values are almost doubled, suggesting heightened stress along with the aggression. Competition over food can also exacerbate abnormal behaviors such as stereotyped movements and self-aggression [Anderson and Chamove, 1981; Chamove and Anderson, 1981; Chamove et al., 1984].

That dominant members of a group have priority of access to spatially restricted food is a fairly robust finding. In rhesus macaques (Macaca mulatta) and Barbary macaques (Macaca sylvanus) dominants are able to control (actively or passively) the area around the food [e.g., Southwick, 1967; Fa, 1986]. In one study on rhesus monkeys' responses to piled and dispersed fruit and vegetables, a subgroup of dominant individuals generally ate earlier and for longer regardless of the experimental conditions, whereas in other subgroups access to food and agonistic behavior varied according to the type and distribution of the food [Belzung and Anderson, 1986]. However, dominance-related effects were less clear in these animals when fear-producing stimuli (model snakes) were presented along with food (Brennan and Anderson, in prep.). Iwamoto [1974] demonstrated a direct relationship between the social rank of adult females and the amount of wheat obtained during provisioning in free-ranging Japanese macaques: dominants ate most. As will be seen in the present chapter, a tendency to monopolize prized food items is also a characteristic of dominant members in captive stump-tailed macaque (Macaca arctoides) groups.

A series of studies by the present authors has examined the role of dominance relations in the distribution of food in captive stump-tails and the extent to which modifying their captive environment could lead to both a greater approximation to natural foraging patterns and a reduction in abnormal behaviors. Methods to equalize distribution were also examined because in captivity monopolizing of food by dominants can become a serious management problem. To set this work in perspective, information regarding normal feeding and foraging in Macaca arctoides is presented below.
FEEDING BEHAVIOR IN STUMP-TAILED MACAQUES

Despite their popularity as a laboratory primate, stump-tailed macaques have not yet been the subject of any detailed field study. Therefore, not much is known about their basic foraging and feeding techniques, let alone the influence of social relations on food-related behavior. Bertrand’s [1969] brief study of a group released near a village in Thailand still provides the best descriptive account of feeding in this species. Additional elementary information is given by Roonwal and Mohnot [1977] and by Fooden et al. [1985] with regard to stump-tails in Yunnan province, China. From these reports it emerges that stump-tailed macaques are omnivorous. Vegetal matter consumed includes fruits, leaves, leaf buds, stems, tubers, seeds, grasses, and bamboo shoots. Bertrand [1969] did not see wild stump-tails feeding on animal matter, but Fooden et al. [1985] list birds, eggs, and larvae as forming part of the diet of Chinese stump-tails. Cultivated crops may also be eaten [see also McCann, 1933].

In Thailand, over 50% of the day was spent foraging and feeding. This compares with between 27% and 52% “feeding” times in Himalayan rhesus, depending on locality [Wada, 1982], 35% of time in long-tailed macaques (Macaca fascicularis) [Aldrich-Blake, 1980], and 37% to 49% in M. fuscata [Iwamoto, 1982]. Comparable figures for some other primate genera are 33% in arboreal red colobus monkeys (Colobus badius) [Marsh, 1981], between 16% and 60% in howler monkeys (Alouatta palliata), depending on the habitat [Clutton-Brock, 1977; Milton, 1980], 50% in green monkeys (Cercopithecus sabaeus) [Harrison, 1983], 42% in mangabeys (Cercocebus albigena) [Waser, 1975], 60% in Galago senegalensis, and 19% in Galago crassicaudatus. Time spent traveling accounted for most of this difference [Crompton, 1983].

As for feeding techniques, Bertrand [1969] noted that when feeding, stump-tails usually transfer items to the mouth by hand, but like other macaques they probably also remove leaves and fruit directly with the mouth, using the hands to bend and pull in branches. Bertrand also described a “factory pattern” of feeding on grasses, where the monkeys shuffle along the ground on their hindlimbs while the two hands work alternately at plucking food items from the substrate and transferring them to the mouth. While food is being collected some of it may be stored in the cheek pouches, later to be pushed into the mouth and masticated. This is a useful adaptation for a crop-raiding species with a “retrieve-and-retreat” feeding pattern, and it also appears to be related to intragroup feeding competition [Murray, 1975].

Further useful information on stump-tail feeding adaptations comes from a group released to range freely over a small island in Mexico [Estrada and
Estrada, 1976, 1977]. Reports concerning this group are mainly interesting for the diversity of items eaten by the group (which was also provisioned). During the first 3 months after being released, the monkeys made use of 18 major plants out of 65 identified on the island, with fruit, leaves, flowers, stems, seeds, tree bark, and roots being eaten. They also systematically searched for animal prey. Freshwater snails were obtained by traveling along the lake shore, sometimes wading in the water, and lifting or moving aside rocks and pebbles. Stones and layers of earth were also removed when the monkeys hunted for terrestrial spiders and earthworms, which were also dug out of the earth. For one type of earthworm, the monkeys' technique consisted of sweeping with the hands to spread out the layer of topsoil, thereby exposing the worms just below the surface. Vertebrates were also caught and eaten, including birds, mice, frogs, and lizards. Individuals not responsible for capturing the prey could sometimes peaceably obtain parts of it from the possessor, but prized food items such as meat led to aggressive episodes, involving both the possessor and individuals waiting on the periphery [Estrada et al., 1978].

In summary, stump-tailed macaques appear to follow the omnivorous macaque general feeding pattern. They are opportunistic feeders and are susceptible to interindividual aggression over prized, clumped food sources. The present brief literature review also reveals some basic foraging techniques that could be simulated in attempts to improve captive environments.

**VARYING FEEDING CONDITIONS IN CAPTIVITY**

Recently there have been a number of studies devoted to the effects of different provisioning methods on monkeys housed in captivity. Topics of interest have included mother-infant relations [Rosenblum and Sunderland, 1982], aggression [e.g., Wasserman and Cruikshank, 1983], and methods for "improving" the behavior of the animals [e.g., Tripp, 1985; our studies described below]. For the most part improvement has been taken to mean a) a reduction in behaviors which the caretakers feel are undesirable in that animals may be injured (e.g., social or self-directed aggression) or which may otherwise indicate emotional stress (excessive immobility, stereotyped motor acts), and b) an increase in alternative, "desirable" behaviors, e.g., overall activity, more equal use of the cage area.

Other forces have influenced this type of research. Animal rights' proponents encourage the development of improved captive conditions. However, the institutions concerned are sometimes resistant to innovations that increase the cost, workload, or variability of established regimes. One way of making progress in this area is to identify relatively cheap and simple methods of improving the captive environment. Where possible, these can be
Food and Activity in Stump-Tailed Macaques

based on a sound knowledge of the natural social organization and gross environmental requirements of the species, such as temperature ranges [McGrew, 1982]. As will be seen below, feeding procedures are also important.

HEALTH AND GROWTH

One clear indication of the impact of feeding procedures on captive populations comes from a review of three years of morbidity and mortality reports for 112,600 primates [Chamove et al., 1979]. Put simply, current feeding procedures are often inadequate in protecting primates from digestive-related illness. Fully half (8%) of the ill population (16%) in any yearly quarter were diagnosed to have a digestive problem. In Macaca arctoides this was just below the average at 13%, possibly reflecting this species’ relatively uncomplicated nutritional requirements, and was highest in orangutans, Pongo pygmaeus, 44%. One-fourth of the deaths per quarter (3%) were digestive-related in the 33 species considered, and this was as high as 10% in the cotton-top tamarin, Saguinus oedipus. This is not surprising when one considers the diets sometimes offered to these animals. In the wild, tamarins spend about 40% of the time feeding on fruits, 40% on high-protein insects, and 15% on plant exudates, i.e., gums and resins [Garber, 1984]. In captivity they are almost never offered plant gums, are fed fruits of a type, of a size, and located quite differently from that in the wild. Protein may also be fed in an unpalatable form [Pereira and Resende, 1986]. Consequently, tamarins often consume a high proportion of high-carbohydrate fruit and relatively little necessary protein. Of the 12 diagnostic categories considered by Chamove et al. [1979], the digestive category was consistently the highest for both illness and death over the 3 years.

In evaluating findings such as those above, it seems very likely that the nutritional needs of certain species have not been met. In addition to choice of foods, however, the amount consumed, the rate of consumption, and social factors certainly play a role; and these are often unfortunately far removed from those recorded in the wild. Commonly, variety is reduced in favor of consistent “high”-quality food, and large or even ad lib amounts are favored over restricted intake. The folly of similar practices is being recognized in the human diet, but, somewhat paradoxically, subjecting captive animals to rigorous feeding regimes more likely to approximate feeding in the wild, including presenting food with marked variations in quality and quantity, would certainly be unpopular in some circles and possibly even illegal. Social factors also seem a likely candidate for some digestive-related diseases in captive primates.

The results of excessive intake of food can be seen from the numbers of
obese animals encountered in laboratories or in heavily provisioned, urban groups of macaques. Obesity in macaques is primarily an adult problem [Kemnitz, 1984], but some effects of extra food availability can be seen at a surprisingly early age. When stump-tailed macaque infants are able to leave their mothers and gain uninterrupted access to unrestricted amounts of cow’s milk, they consume about half the amount of this milk as infants fed totally by hand. This suggests that they do not obtain as much milk as they would like from their mothers. Further, the average laboratory-reared monkey which is not reared by its mother and with unlimited access to milk consumes about twice the amount of a mother-reared infant [Chamove, 1981; Chamove and Anderson, 1982; Scheffler and Kerr, 1975]. The slightly higher carbohydrate and slightly lower protein content of the commercially available milk formulas cannot account for the intake differences, although milk production in mothers is of course limited by nutritional factors [Altmann, 1983]. The high milk intake of hand-fed stump-tails might be expected to lead to heavier juveniles and adults compared with mother-fed infants. Surprisingly, where data have been collected this does not seem to be the case during adolescence [Faucheux et al., 1978; Chamove and Anderson, 1982]. Between 200 and 300 days of age the weight pattern changes from one where mother-reared infants are two standard deviations lighter than hand-reared infants to one where they are over two standard deviations heavier. Diets are different and growth is different.

Alterations in the quality of food taken in infancy may also have effects later in the life of macaques. When infant stump-tailed monkeys were given supplementary feedings of SMA, a proprietary milk formula for human infants, while still receiving most of their nourishment from their mothers, this led to a greater preference for SMA when offered at a later age [Chamove and Anderson, 1982]. The amount of such supplementary feeding did not seem to greatly influence the degree of preference; but it did influence the amount of SMA consumed over a 1-month period after weaning from the mother. In conclusion, while obesity arising from standard captive feeding practices is a recognized problem, the relative influence of developmental, nutritional, and social as well as nonsocial environmental factors remain to be elucidated [see Kemnitz, 1984].

**BEHAVIOR**

For several years the present authors have been involved in research into improving captive environments for primates, concentrating on stumptailed macaques. These large, highly social monkeys have a clear advantage for research over our second main type of research subject—the small, arboreal callithrichids; stump-tails appear to need a more complex environment,
showing behavioral deterioration when housed in small enclosures. Therefore any behavioral improvements resulting from enrichment procedures can be easily measured.

Two primary aims have guided this work: 1) to choose enrichment techniques that encourage the expression of more naturalistic behavior patterns, and 2) to identify techniques that would be widely acceptable to people keeping primates in captivity. The work of Markowitz [1982] exemplifies interesting enrichment procedures for captive animals, but they require specialist technical skills and can be quite costly to construct and implement. Our approach has used food as a motivator for the monkeys—not via food deprivation, but rather by using rarely presented foods that were highly desirable and that could be presented in small amounts. Because food is such an important aspect of the environment, the results of these studies should be of general interest.

During our initial studies mixed grain was offered to the animals, either scattered on the bare floor of the pen or buried in sawdust, woodchips, or woodwool [Chamove and Anderson, 1979; Chamove et al., Anderson, 1982; Anderson and Chamove, 1984]. Plate I illustrates the outdoor pens when clear of floor covering and with grain recently scattered. Feces can be seen, although the floor areas were cleaned only 1 hr previously. The same area with woodchips on the floor is shown in Plate II. More group members are attracted to the floor in this condition, and feces are rapidly covered and dessicated by the litter. Plate III shows animals with the same weight of woodwool. As can be seen, there is a clear preference for the half with the floor covering. Because of the springy nature of the deeper woodwool, younger individuals incorporate this substrate more into their activity, especially play, than is the case with the denser coverings.

Scattering grain in the floor coverings mentioned above produced quite dramatic changes in behavior. In pens housing adult stump-tailed monkeys, aggression was almost twice as frequent when the floor was bare than when it was covered; in pens housing juveniles, aggression was ten times more frequent with no floor covering. The litter-induced reduction in agonistic episodes was most marked in intermediate- and subordinate-ranked individuals, a finding in agreement with the greater variability of response to changing feeding circumstances in nondominant macaques reported by Belzung and Anderson [1986] and by Rosenblum and Smiley [1984].

Other effects of the floor covering included a tendency for affiliative behaviors to increase, again most noticeably in lower-ranking subjects, and for all subjects to spend more time on the ground. Another effect that may be of significance for other laboratory groups of primates was an overall reduction in abnormal behaviors, by about half [Chamove et al., 1984].

Not surprisingly, all the animals fed more rapidly when the floor of the pen
was bare and the grain thus easily visible on the floor (see Plate I); this was especially so for dominant individuals. The difference in feeding rates between monkeys occupying differing hierarchical positions was reduced in the presence of woodchips, to the extent that it became detectable only in the first minute after grain was introduced.

Subsequently, different-sized grains were used, varying in size from just over 8 mm in diameter (maize) down to just under 2 mm (millet) [details in Chamove and Anderson, 1979]. However, the total weight of grain offered was kept constant over conditions. As grain size was reduced, feeding rate increased by a factor of about three, this being measured by the number of hand-to-mouth contacts per unit time. In bare floor conditions the stump-tails’ feeding behavior resembled the “factory pattern” described by Bertrand [1969]. At the same time, the reduction in personal space on the bare floor led to frequent disputes. With the floor coverings, on the other hand, the animals’ attention seemed to be diverted from their neighbors and instead channeled more to the task of searching for and extracting the food items from the substrate, leading to greater tolerance of intrusions into personal space. Notably, in the deep-litter condition the monkeys used sweeping motions with one hand to remove the top layer of the litter and
Plate II. Outdoor pens with woodchips covering the floor area and grain added.

expose the food items, which were picked up with the other hand. This is reminiscent of the pattern described in semi free-ranging stump-tails by Estrada and Estrada [1976, 1977].

Another series of experiments looked at the generality of the above findings to other species of primates. For example, it was expected that more arboreal primates would be less affected by the presence or absence of a floor covering. Eight different species were tested, using groups at Edinburgh Zoo [Chamove et al., 1982]. The amount of time spent on the ground when the floor was bare or covered with woodchips is depicted in Figure 1. Use of the floor increased clearly for all species [see also McKenzie et al., 1986], with only slight evidence of a greater effect for the more terrestrial species. The reduction in aggression found in the earlier work was also extended to other species, albeit less dramatically (see Fig. 2).

Whenever the idea of floor coverings is mooted, the possibility arises of disease and parasite transmission and reinfection. To assess the safety of deep-litter techniques and to compare it with the usual practice of bare floors, we collected samples of the floor covering at weekly intervals for 8 weeks. Two assessment procedures were used: a) One measured naturally occurring bacterial levels of three common bacteria; b) The second involved innocu-
Plate III. Outdoor pens with woodwool covering half the floor area and grain added.

<table>
<thead>
<tr>
<th>Species</th>
<th>Time spent on the floor (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cercopithecus ceph us</td>
<td>40</td>
</tr>
<tr>
<td>Cercopithecus aethiops</td>
<td>20</td>
</tr>
<tr>
<td>Lemur catta</td>
<td>10</td>
</tr>
<tr>
<td>Macaca arctoides</td>
<td>60</td>
</tr>
<tr>
<td>Saimiri sciureus</td>
<td>80</td>
</tr>
<tr>
<td>Cebus apella</td>
<td>80</td>
</tr>
<tr>
<td>Saguinus labiatus</td>
<td>60</td>
</tr>
<tr>
<td>Callithrix jacchus</td>
<td>40</td>
</tr>
</tbody>
</table>

Fig. 1. Percentage of time spent on the floor when uncovered (open) and when covered with woodchips (hatched).

Incorporating floor-covering samples with *Salmonella typhimurium* and measuring how well this organism survived. The results showed that, in common with similar tests using poultry litter, as the floor covering is used more over the weeks, it becomes more inhibitory to bacteria. Total bacteria count actually
increased over the 8 weeks, and salmonella survival was reduced as the floor covering became more soiled [details in Chamove et al., 1982].

A further series of manipulations involved varying the spatial distribution of food. These were based on procedures developed for the maintenance of the animals and efforts to allow subordinate individuals to obtain a larger proportion of food when fruit and vegetables were presented. For example, when fruit and leafy vegetables were fed to the macaques, the food was often placed outside the mesh of the enclosures, often on the roof, so that the animals had to climb and pull it in through the mesh [Chamove, 1981]. This led to longer feeding times and better distribution of the food.

The main experiment involved the following conditions: 1) To assess the influence of the desirability of the food, three types were offered—namely, banana, apple, and carrot—in decreasing order of preference. 2) To assess the effect of mode of distribution, food was either massed in two piles or distributed evenly over the floor area. 3) To assess the influence of interanimal visibility, the food was either distributed in a single area with clear visibility throughout or in an area which was divided by four opaque partitions, these having only small openings for the monkeys to pass through. 4) The influence of the visibility of the food was assessed either by distributing it on the bare floor area or burying it under woodchips. 5) Food was presented either fresh or solidly frozen. With regard to the last condition, feeding lasted about 2 min when fresh food was used, compared with about 24 min when the same food was frozen. An adult stump-tailed monkey eats a fresh apple in about 1.8 min and a banana in half this time; the frozen fruit takes about six times as long to eat.

In general, the greatest amount of aggression was shown when the food was presented distributed over the floor. Aggression was reduced when food
was massed into two piles, further reduced when buried in the woodchips, and reduced to its lowest level when the monkeys could not see many other animals because of the opaque partitions. The finding of increased aggression with spatially distributed food is interesting, and goes against some of the traditional findings of reduced aggression with less spatially concentrated food items. This suggests that there is a minimum area, still to be determined, beyond which scattering food will reduce aggression but below which the same practice may increase conflict. This is due to attempts by dominants to control more-or-less all the food, as was the case in this experiment when the food was fresh, distributed, and visible. Also, aggression levels were relatively higher when the more preferred fruits were offered than when carrot was used [details in Chamove et al., 1982]. Comparable results have recently been reported by Caba-Vinagre et al. [1986] for a group of stump-tails in seminatural conditions, where there were 93 agonistic episodes per hour during provisioning of the 24 monkeys, compared with only 2 per hour during free-foraging time.

A final set of comparisons assessed the role of food in the maintenance of foraging behavior. One might expect that some reinforcement by finding food would be essential in maintaining foraging, or that frustration if food was not found would lead to the appearance of other behaviors. The following conditions were compared: 1) bare floor, 2) woodchips on the floor but with no food, 3) woodchips with grain mixed into it, and 4) woodchips containing grain plus an unlimited amount of the same grain freely available in food hoppers.

The results are illustrated in Figure 3. The presence of clean grain-free litter altered the monkeys' behavior. Not only did the animals spend more time on the ground in the presence of litter alone, but they played more there and searched through the litter, apparently looking for things to eat. Both aggression and abnormal behaviors were reduced in the presence of litter [see Anderson and Chamove, 1984]. Were this a frustrating or competitive situation, abnormal behaviors would be expected to increase [Chamove et al., 1984; Nash, 1982], but they did not.

A similar picture emerged when free grain was available: The monkeys still foraged through the woodchips, searching for and eating any grain they found even though handfuls of the same food were readily available in food hoppers. As before, aggression and abnormal behaviors were less frequent than in the bare condition, with play on the floor and intense foraging activity being prominent. It appears that in captive conditions like these, animals will seek out situations where they can search for food, even when free food is easily available or even when no food is present. Interestingly, other experimental paradigms have shown persistent searching for food in preference to freely available but otherwise identical food in rodents and birds.
Food and Activity in Stump-Tailed Macaques

Fig. 3. Percentage of scans in which an animal was observed in a particular activity. Clear histograms indicate no floor covering, small dots indicate grain, large dots grain in food hoppers.

[Inglis and Ferguson, 1986]. In other words, there is a residual motivation to search for food, and this motivation is resistant to extinction or to satiation by feeding. Therefore, simple feeding techniques of the type described in this chapter also have the advantage of permitting the animals to engage in information-gathering exercises that are otherwise largely obviated by traditional captive-feeding regimes.

CONCLUSIONS

The findings described in the present chapter show that variations in how food is presented to nonhuman primates can have marked effects on behavior. Importantly for the management of captive primates, some simple food-related techniques can be used to enhance life in captivity: reducing abnormal behaviors, encouraging the expression of more natural foraging patterns, and increasing the complexity of the environment and thus reducing boredom. Recent studies have confirmed the beneficial effects of floor coverings on activity of apes and monkeys in captive settings [Tripp, 1985; Westergaard and Fragaszy, 1985], and it is gratifying to see that the use of
deep-litter substrates containing edibles is now being more widely recommended [e.g., Canadian Council on Animal Care, 1984]. There is room for further research in this area. For example, variety in both fresh and dry commercial foods is considered desirable [Chamove, 1981], but the effects have yet to be measured. The potential of simple alterations to the appearance of food could be assessed [see Barbiers, 1985], as could the effects of improved food presentation methods on some physiological indices of stress. Such research is economical and has the advantage of leading to better captive environments and to a better understanding of behavior.

REFERENCES


Food and Activity in Stump-Tailed Macaques


INTRODUCTION

When the need to confine animals leads to an environment that is less complex and more predictable, the degradation often creates a downward spiral:

unstimulating environment -> suboptimal behavior -> reduced use of environment -> worsening behavior, etc.

Many researchers are increasingly interested in interrupting this trend. Most of the published research toward this goal has been with animals living in small groups in zoological gardens, but some has been done with individually-housed animals (Markowitz 1982), and some in laboratories (Erwin & Deni 1979). Concern has centered on improving the welfare of captive animals, yet until very recently there has been little interest in operationally defining environmental improvement or enrichment, or evaluating the cost-effectiveness of various enrichment strategies, or developing theoretical models to guide research and integrate divergent studies (but see Chamove 1986; Dawkins 1980; Hughes 1980).

The study of enrichment can be viewed as a conceptual extension of past research on the developmental effects of early experience. In that earlier work, questions about the role or importance of various factors (e.g., vision – Anderson & Chamove 1984b; Bovard 1959; Chamove 1984b; Sackett 1966) in social development were studied by withholding or limiting sensory or social stimulation. In enrichment studies, on the other hand, such questions are addressed by adding a variable to a relatively-impoverished standard environment, and assessing its consequence for behavior. These studies often have two goals: (1) to assess the importance of a given factor for the subject’s behavior and (2) to improve the captive environment. Both
are achieved by adding to an impoverished environment that is presently the status quo.

PROBLEMS OF CONTAINMENT

Confinement can amount to environmental impoverishment in a number of ways. Issues to address include (i) cage size in relation to group size and structure, (ii) cage design, and (iii) cage furnishing. One can think of the last two as ways of increasing the psychological size of the cage (discussed at length in Chamove in press).

Cage size

One common problem is a cage that is too small. There is evidence that small cages are stressful enough to inhibit even that most robust measure of general wellbeing, reproduction (Doolittle Wilson & Geisking 1976; Snowdon Savage & McConnell 1984). The mechanism for this might be the adrenocortical stress response (Kalin Carnes Barksdale Shelton Stewart & Resch 1985). Several other behavior patterns are adversely influenced by cage size and its related variables of crowding and group size (Adams & Babladelis 1977; Archer 1979; Chamove Hosey & Schatzel in press; Dantzer & Mormede 1983; Kaplan 1986; Siegel 1980). Of course group size also has effects on behavior in the wild where space restrictions are less salient or even absent (Boelkins & Wilson 1972; Garber 1986; Kinzey 1986; McFarland 1986; Singh 1969).

Small cages are known to increase the incidence of stereotyped movements as well as other types of abnormal behavior not involving locomotion (Draper & Bernstein 1963; Hediger 1968; Paulk Dienske & Ribbens 1977). It is hard to imagine a case where simply increasing usable cage space would not constitute an enrichment procedure, even though gross activity levels might not change dramatically (see Line 1987).

Even when it is impossible to provide more space, and cages are quite small, enrichment is still possible. Reinhardt and his coworkers have shown that compatible pairs of rhesus monkeys can be formed from unfamiliar, individually-housed adults, allowing "the expression of a hitherto inhibited basic need: the need for a companion and for social interaction" (Reinhardt Cowley Eisele Vertain & Houser 1987a p.8).

Where social grouping is not possible, even visual contact with other animals is better than nothing. The presence of a full-length mirror in the cage reduced the development of abnormal behavior in young stumptailed macaques otherwise reared alone (Anderson & Chamove 1986). Group-living monkeys rapidly habituate to a large mirror just outside their cage (Anderson & Bayart 1985), but small, portable mirrors were repeatedly manipulated and remained a source of fascination over months (Anderson
For isolated individuals with no possibility of social interaction, one can at least provide varied objects that elicit manipulation. Food-acquisition games and devices such as those designed by Markowitz (1982) improve the quality of the animal's environment as well as the quality of the animal (Markowitz & Spinelli 1986). (Also see Rumbaugh Washburn & Savage-Rumbaugh: this volume.) Simply installing a branch in an otherwise barren cage gives a monkey an object to manipulate, hold, shake, gnaw, perch, and stand on (Reinhardt Houser Cowley & Champoux 1987).

**Cage design**

Commonly, enclosures are designed by architects whose primary considerations are engineering, maintenance, cost, and human comfort and convenience. Bare walls allow paintings to be hung, straight walls are best for human furniture, conventions for location and level of lighting are for reading. Bare, flat, smooth walls are easy to build and to clean, but most animals cannot make use of them – they do not hang pictures on them and, more importantly, they cannot climb them. One often sees zoo primates housed in spacious cages, but unable to make use of the large open spaces. One problem of enrichment is how to use these valuable areas most efficiently (Berkson Mason & Saxon 1963).

**Cage furnishing**

**Floor covering.** An area of the cage that is often neglected or ill-designed is the floor. The floor and areas just above the floor are often kept clear for cleaning and for humans to work. In eight callitrichid enclosures in our laboratory, the floor makes up about 40% of the total usable surface area and 66% of the horizontal surface area. In the wild these arboreal monkeys rarely come to the ground, only occasionally descending to forage in leaf litter or to cross open areas (Heymann 1987; Neyman 1980; Sussman and Kinzey 1984). In captivity these monkeys almost never visit a bare floor (1% of the time), but ground time increases ten-fold if the ground is covered with some leaf-like substrate
Branches. Another aspect of primate cage design that has been virtually neglected is branch placement. One field study suggests that callitrichid monkeys primarily use horizontal branches moving on vertical substrata only 4% percent of the time, and this mainly on large tree trunks (Garber & Sussman 1984). Nevertheless, many of the cages housing these monkeys have few horizontal tree branches but many hanging vertical branches, perhaps because it is easier to attach these vertical clumps. Rough tallies (personal observations) indicate that about 25% of the branches are horizontal, 30% oblique, and about 45% vertical, with vertical branches usually being thinner than horizontal ones. In the wild, thin vertical branches are almost never traversed except to reach food. In large outdoor areas (Chamove & Rohrhuber in press) and in the wild (Garber 1980), the monkeys spend most of their time (89%) in dense networks of thin, flexible, nonwoody tangles. (Also see Wright Haring Izard & Simons: this volume.) We are currently looking at branch use and branch preferences in caged callitrichid monkeys (Chamove & Goldsbrugh: unpublished). Our results make it clear that these monkeys prefer a larger number of unevenly spaced horizontal branches; widely spaced ones are especially used by the more-active juveniles, and narrowly spaced ones by the less-active adults. These results are for preference, and it should be noted that measures of preference and measures of enrichment are not necessarily the same. Animals’ preferences are not always or necessarily in their best interest (Chamove 1979; Dawkins 1976; Duncan 1978; Hughes 1976).

Range of behavior

Small cages, poor cage design, and impoverished furnishing combine to limit the range of behavior shown by an animal. The most obvious of these, and perhaps the most important, is the opportunity to move about and forage. Primates spend an average of over 50% of their day searching for and processing food. In cages this is dramatically reduced. Some animals continue to perform relatively normally, commonly exemplified by hamsters making piles of food; some perform species-typical behavior in inappropriate ways, like raccoons washing soluble food in their water dish, or stereotyped pacing; some display food-related behavior not seen in the wild, like regurgitation and coprophagy in primates (Fox 1986; Gould & Bres 1986). It is often suggested that repetitive stereotyped movements “can be seen as the animal's attempt to increase its sensory input” when it is too low (Bareham 1972; Duncan 1977; Wemelsfelder 1985 p.143). This view presumes that the animal is receiving input that is inadequate in amplitude, variability, or quality. Some stereotyped movements may be an expression of arousal or stress, perhaps due to boredom, frustration, or merely stimulus change (Berkson Mason & Saxon 1963; Chamove & Anderson 1981; Chamove Bayart Nash & Anderson 1985). The ability of stereotyped
behavior to reduce adrenocortical hormone levels supports this interpretation (Anderson & Chamove 1981; Blackshaw & McVeigh 1984; Dantzer & Mortmede 1983). Stereotyped movements are probably best considered as habitual patterns of stimulation which, by virtue of their familiarity and repetitive nature, calm the individual when input is too high or arouse it when too low.

Cages may be designed so that it is impossible to perform certain actions at all, like tool-making and tool-using in apes and capuchins (McGrew 1981; Nash 1982), wood-gouging in marmosets (McGrew Brennan & Russell 1986), and, indeed, foraging in most primates (Rosenblum & Smiley 1984). Several lines of research have shown that increasing the range of foods eaten is healthier (Kirkwood 1983), increasing the range of muscles used is healthier (Turnquist 1985), and generally increasing the range of stimuli is both healthier (e.g., Bollhorn 1980; Ekesbo 1981; Fox 1986; Gross 1972; Kendrick 1972; Renner & Rosenzweig 1987; Riley 1981) and less boring (Wemelsfelder 1985). Consequently, enrichment efforts should try to increase the range of behavior that an animal can express as well as the range of stimulation available to the animal.

GOALS OF ENRICHMENT

Two complementary aims of enrichment studies re to increase "desirable" behavior and to reduce "undesirable" behavior. Activities such as coprophagy, regurgitation, hair-pulling, self-injury, or stereotyped movements are generally judged undesirable, while active exploration, play, affiliation, and foraging are judged desirable. Other behavior is classed as one or the other depending on its frequency: withdrawal or avoidance, reproductive behavior, aggression, inactivity, displacement, and feeding are judged desirable if moderate in frequency but undesirable if very frequent (e.g., Blackshaw & McVeigh 1984; Chamove Anderson & Nash 1984; Goosen Fransen & Gomers 1986; Gould & Bres 1986; Reinhardt Reinhardt & Houser 1986; Tripp 1985). An increase in desirable behavior is taken as an index of improvement in physical or psychological health.

Criteria of Desirability

There are at least four bases for assessing desirability of behavior: (i) normality, (ii) observer/caretaker acceptability, or (iii) theoretical or (iv) practical considerations.
(i) Normality. Probably the most common, implicit criterion is normality of behavior: Behavior that approximates what is found in the wild is held to be desirable, while behavior uncommon in the wild is undesirable. In other words, the form and frequency of behavior should fall within the range of values seen in the wild (McGrew 1981; Snowdon in press; but see Wemelsfelder 1985 p.137). One problem is that typical behavior patterns in the wild vary, sometimes widely, with group size, habitat, season, and even the daily weather (Chapman 1985; Harrison 1983; Oates 1987; Richard 1985).

(ii) Public acceptability. The second approach takes into account what is acceptable to the public -- often meaning the most outspoken elements of the public. It appears that the public does not like to witness stereotyped or sexual behavior, or "unpleasant" behavior such as regurgitation, reingestion, and coprophagy by captive gorillas (Akers & Schildkraut 1985; Gould & Bres 1986); they like animals to be active and clearly within view; and they do not read or necessarily believe posted notices (Cherfas 1984). These assertions need testing by data, but in the meantime they appear to be assumed by zoo curators and to influence the housing of zoo animals (Adams & Babladelis 1977).

(iii) Theoretical considerations. Some enrichment goals are chosen because they have a theoretical rationale. Examples might be setting goals for exercise or calorie expenditure for captive animals based on their activity budgets in the wild; or providing problem-solving opportunities that simulate challenges encountered in the wild, for example burying food in woodchips. Swimming pools and fishing ponds are further examples of innovative ways to increase activity in the laboratory (Gilbert & Wrenshall: this volume; Molzen & French: this volume).

(iv) Practical considerations. Finally, the practical need to improve husbandry often influences enrichment studies. Goals to be tackled include reducing aggression and self-injury, reducing food and other resource wastage, and reducing costs in general. One technique to reduce food wastage while making better use of space is to mix species (O'Neil: this volume; Waser 1986). Ground living rodents, birds, or fish eat fallen fruit in bird, bat, or primate exhibits in Edinburgh, Milwaukee, Sydney, Copenhagen, Stockholm, and San Diego Zoos.

Of course, though we may discuss them independently, the various bases for assessing desirability of behavior are related, and what satisfies one criterion will often satisfy others. As an example, management practices aimed at reducing stereotyped movements, say by increasing food variety (a practical measure), may lead to behavior that is more like that seen in the wild (normality approach), increases the similarity of the activity profile to that observed in the wild (theoretical approach), and probably also increases
public acceptability along with improving the animals' physical health (practical). When hiding food in floor coverings led to increased activity in zoo orangutans, the visitors rated the exhibit more favorably (Tripp 1985).

PSYCHOLOGICAL FACTORS IN CAPTIVITY

Control

Cages usually reduce the degree of control that individuals have over environmental stimuli. When rooms are visually divided by opaque barriers, male macaques cannot control female aggression through posture and facial expression, and so female aggression increases (Erwin 1971).

The importance of control is also exemplified by the effects of visitors on the behavior of zoo animals (e.g., Hosey & Druck 1987; Glatston Geilvoet-Soeteman Hora-Pecek & van Hooff 1984). One can postulate that zoo visitors are beneficial stimuli in an otherwise-barren environment. Certainly some primates interact with visitors both positively and negatively (Fa: this volume). An alternative view, supported by an increasing amount of evidence (Chamove Hosey & Schatzel: in press), is that visitors cause the same kind of changes in the behavior of display primates as other stressors do; increased locomotion is the most consistent effect. The data suggest that the more visitors there are, the more behavioral change there is; noisy and active visitors cause more change; and visitors viewing monkeys from above (rather than at a lower level) cause more change. This research adds to the evidence for the importance of providing animals with privacy refuges (see Fouts Abshire Bodamer & Fouts: this volume, and Miller-Schroeder & Paterson: this volume) from which they can control visitor contact (Adams & Babladelis 1977). Other evidence for the importance of control is the surprising preference animals have for working for part of their food in the presence of free food (discussed later). Of course hidden choice titbits can also stimulate persistent searching (Figure 1; Anderson 1986).
Figure 1. A young adult male *Macaca tonkeana* uses a mirror to guide his hand movements as he searches for a hidden raisin stuck onto the outside of the cage at position 4. The mirror is in the lower left corner of the photograph.
The importance of control to the psychological health of animals is currently a topic of great interest. In the wild, animals have more control over certain stimulus variables and most response variables than they do in captivity. Cages restrict animals' control, particularly with regard to their distance from stimuli outside and inside cages, as well as by limiting opportunities to act effectively on the environment. The discrepancy between control of stimulus and response variables in captive vs natural environments, first elaborated by Hediger (e.g., 1968), may be the most fundamental issue in enrichment.

An extensive study of the effects of early control over environmental events on socioemotional development showed that young rhesus monkeys that could operate devices dispensing food, water, and other treats showed less self-directed behavior and more exploration than monkeys receiving the same commodities independently of their own behavior (Mineka Gunnar & Champoux 1986). Thus, in order to produce behaviorally competent individuals, animals should be allowed to act on their environment to produce significant consequences. Extreme loss of control, especially over aversive events, leads to syndromes such as "learned helplessness" (Seligman 1975).

Complexity/Predictability

On a more conceptual level, cage environments can be thought of as reducing the complexity or as increasing the predictability of stimulation. These two are inversely related; if one declines the other usually rises. In an environment where predators are nonexistent or highly predictable (e.g., laboratory or zoo), or where only one type of food is offered, options are fewer, stimuli more repetitive and predictable, and decisions are simpler.

Stress

Stress is another theoretical construct in enrichment studies. It is believed desirable to eliminate stress, so as to increase desirable and decrease undesirable activities. Poor cage design, cramped cages, crowding, etc. are believed to stress animals, and this is supported by studies on physiological and behavioral measures of stress (also Bollhorn 1980; Clark 1980; Eisen 1966). So one challenge for enrichment studies is to reduce stress, or better, to identify and strive to achieve an optimal level of arousal rather than a constant minimum. In the normal animal arousal varies with the ordinary challenges of life (e.g., Beuving 1980). So any optimal level is bound to vary, and to include occasional brief peaks. We now have results to suggest that such brief challenges, such as birds passing over tamarin enclosures, are beneficial (Moodie & Chamove: in preparation).

Some researchers view "stress" as equivalent to "distress", although
this is not a necessary interpretation. Garmezy (1982, p.238) defines stress as "any action or situation that places special physical or psychological demands upon a person—anything that serves to unbalance an individual's equilibrium or homeostasis." Wemelsfelder (1985) uses "distress" for the effects of understimulation, "stress" to those of overstimulation. If stress is any event that is destabilizing or that taxes the system, then positive events, too, are of interest.

**Beneficial effects of stress?** The literature suggests that stress levels that are markedly and persistently below those likely to be found in the wild lead to individuals who do not deal well with subsequent stressors (over-reacting both in intensity and duration to mild stimuli as well as to stressors -- e.g., Stolba & Wood-Gush 1980), and who appear to have difficulty inhibiting habitual responses (Chamove 1984a; Sackett 1970). In animals, some stress early in life enables adults to cope better with stressors (Chamove 1980; Denenberg 1964; Denenberg & Whimbrey 1963; Ewbank 1973; Fox 1986). Captive animals also appear to seek challenge by choosing to work for food despite the availability of free food (Anderson & Chamove 1984; Carder & Berkowitz 1979; Harlow 1950; Havelka 1956; Inglis & Ferguson 1985; Kear 1961; Markowitz 1982; Neuringer 1969; Wood-Gush 1973).

**EVALUATION OF EFFECTIVENESS OF ENRICHMENT**

Evaluation should be seen as crucial to studies of enrichment; we need answers to questions about the real (not merely presumed) benefits of enrichment efforts, the reliability of the effects, and whether the benefits justify costs.

**Cost**

Costs are most often discussed in terms of time or money, but can also be measured in terms of alternatives forgone. One form of enrichment may preclude others, or may mistakenly lead caretakers to believe they have done enough. If a ball is chosen as the enrichment device (e.g., Renquist & Judge 1984), this may be at the expense of other possible devices; investing in one expensive device may exhaust the budget for enrichment. Evaluating an enrichment technique can be likened to evaluating a new drug. If there is no other drug available for treating an illness, the drug is compared with a placebo (unless its benefits are so great or so obvious as to make such a trial unnecessary -- e.g., vaccination for smallpox). If the drug is to supplant an existing drug, it is compared with that drugs.

**Benefit**
Just as cost can be seen from several aspects, so can benefit. The short- and long-term effects of intervention both need to be measured, and criteria for the duration of effect need to be specified. For example, a small, controlled fire in a large chimpanzee enclosure produces a dramatic response the first time, but the apes lose interest after the second time (personal observation). It is usually long-term changes in behavior that are of interest and measured in competent studies of enrichment (e.g., Westergaard & Fraganzi 1985). Changes in behavior need to be maintained for long periods or to show up frequently during the day to be deemed significant and worth the effort.

Finally, to measure benefit one needs to decide on the importance of the behavior that is altered. Two extremes will illustrate the difficulty of such decisions. Certain behavior may be considered important because it occurs frequently in the normal situation; examples are foraging, locomotion, and huddling. King and Norwood (this volume) consider the opportunity to leap important in squirrel monkeys, as over 40% of their travel is accomplished by leaping. Other behavior may be important because, although its normal frequency is low, it has known value for the individual or species. Dust-bathing in fowl is an example (Dawkins 1976), or food-offering and sharing in cotton-top tamarins (Feistner & Chamove 1986). And other behavior, initially rare, may be important for its potential to supplant common behavior. The use of tools enables monkeys to process certain nuts four times as rapidly (Visalberghi & Antinucci 1986). This tool use reduces feeding time but at the same time it represents an increase in the range of behavior available to meet future environmental challenges (Figure 2; Anderson, in preparation).

Two studies illustrate the benefits of proper evaluation of enrichment procedures. Rosenblum and Smiley (1984) found that providing a foraging task reduced such behavior as self-aggression and abnormal posturing in high- and low-ranking members of a group of isolation-reared bonnet macaques, but increased these actions in intermediate-ranking monkeys. Others (Bloomstrand Riddle Alford & Maple 1986) reported behavioral deterioration in some members of a chimpanzee group that had access to a food puzzle, while other members showed improved behavior. It seems likely that such negative reactions stem from social tensions arising when an enrichment task stimulates (even if inadvertently) competition. Such enrichment devices may be better suited to individually-housed animals; or competition may be averted by providing several devices to the group.
Figure 2. A male *Cebus apella* uses a stone (a,b) or a block of wood (c) to break open an almond.
AN EXAMPLE OF AN ENRICHMENT TECHNIQUE

To illustrate several of the points raised in this chapter, we will describe a series of studies, conducted between 1979 and 1986, that assessed the effects, in eight different primate species (listed in Figure 4), of covering the floor of large group cages with a deep absorbent litter (Anderson & Chamove 1984a; Chamove & Anderson 1979; Chamove Anderson Morgan-Jones & Jones 1982; Chamove Anderson & Nash 1984; McKenzie Chamove & Feistner 1986). The goal was to improve behavior, especially to increase activity and to reduce abnormal and undesirable behavior that some of these species were displaying.

The problem. In the wild, primates may spend 25% to 90% (mode about 55%) of their waking hours searching for and eating food (reviewed in Clutton-Brock & Harvey 1977). The pattern of foraging and feeding varies between species and with time of day; often highly digestible foods that can be rapidly harvested are eaten early in the day (Oates 1987). In captivity, however, search time is decreased almost to zero, and eating time varies from a low of only about 5% in callitrichids (personal observation; also see Molzen & French: this volume) to a high of 10% in the great apes (Kirkwood 1983; see also Rosenblum & Smiley 1984). When, as is common, food is offered in only one or two discrete locations, the frequency of conflicts at feeding times may exceed non-feeding values by a factor of up to ten (Anderson & Chamove 1984a; Belzung & Anderson 1986), and there is a concomitant 50% increase in blood cortisol levels, suggesting considerable stress (Chamove & Bowman 1978).

The technique. Our method of enrichment was to cover the floor to a depth of 4 cm with woodchips. Items of food were sometimes mixed into this litter. The aim was not to emulate—to copy nature, as this is impractical for almost all captive environments, but rather to simulate—to provide certain possibly-critical components of the natural environment. The food that was mixed into the floor litter varied: one to a mixture of eight different types of cereals [diameter 1.6 mm (millet) to 8.3 mm (maize)]; or insect larvae (mealworms); or large pieces of fruit.

The hypothesis. We worked from the hypothesis that enrichment would be more effective when it targeted behavior that is common in the animal's natural setting. We predicted (i) that changing the opportunity for an important and common behavior pattern like foraging would lead to substantial changes; and (ii) that arboreal species would be less affected by floor covering than would more terrestrial species, since the former are less likely to forage at ground level.
Effectiveness. The effectiveness of the woodchips, with or without food, was measured over several months to determine costs and benefits and the stability of the behavioral effects. Technician workload was assessed, cage cleanliness and odor were evaluated, and changes in the animals’ behavior were recorded. Bacterial vigor in the woodchips was also measured.

Results

These studies clearly showed the high cost-effectiveness of the floor covering in improving behavior. The desired goal was achieved in the initial studies on stumptailed macaques (Macaca arctoides); self-aggression (Anderson & Chamove 1981) was reduced by more than half and aggression was reduced by a factor of two in adults, and ten in juveniles. Similar reductions occurred in all but one of the species subsequently studied in which aggression had been seen prior to introduction of litter (Figure 3). When, prior to introducing woodchips, fruit was scattered over the bare floor (as is commonly done), aggression levels were high, as dominant individuals tried to monopolize the food. When we buried the fruit under woodchips, fighting decreased by half, and the fruit was more evenly distributed among the group members. To our surprise, when all the fruit was placed in a single, easy-to-monitor pile, aggression levels were as low as when the fruit was buried; the dominant animals controlled the pile of food and other animals simply waited their turn; food distribution was highly skewed across subjects (also Belzung & Anderson 1986; Brennan & Anderson 1988). When the piled-up fruit was frozen, food-processing time increased (a piece of frozen fruit takes six times as long to eat as a piece that has not been frozen); aggression also increased, because dominants now controlled the pile for longer. However, when frozen fruit was scattered, distribution over group members was more even, and aggression was as low as when unfrozen fruit was covered with woodchips. Increasing foraging demand can increase or decrease agonistic behavior, depending on how foraging demand fits in with group social structure (also Rosenblum & Smiley 1984).

When the floor of the enclosure was bare, macaques, of course, spent almost no time searching for food items on it. When the floor was covered with woodchips only, the animals spent about 5% of their waking time sifting through this floor covering. When grain was added to the woodchips, the monkeys’ searching increased to almost 15% of waking time, even when grain was also freely available elsewhere. When free grain was removed, so that the only grain available had to be found and extracted from the woodchips, the monkeys spent over 30% of their day foraging.
Examining Environmental Enrichment

Cercopithecus cephus
Cercopithecus aethiops
Lemur catta
Macaca arctoides
Saimiri sciureus
Cebus apella

Figure 3. Percentage of time engaged in agonistic behavior when the floor is bare (open bars) or covered with floorcovering (filled bars).

Time spent on the ground (%)

Cercopithecus cephus
Cercopithecus aethiops
Lemur catta
Macaca arctoides
Saimiri sciureus
Cebus apella
Saguinus labiatus
Callithrix jacchus

Figure 4. Use of the floor when uncovered (open bars) or covered with woodchips (filled).
All of the primate species assessed showed increased use of the floor when it was covered with woodchips (see Figure 4). We were surprised to find no support for our prediction that arboreal primates would benefit less than terrestrial primates; there was no systematic relation between the amount of increase in time spent on the floor and whether a species was primarily terrestrial or arboreal.

All monkeys spent more time looking for food hidden in the woodchips, taking over four times longer to locate a hidden item than the same item on the bare floor. Monkeys of every species moved around more on the floor when the floorcovering contained food. They took longer to exhaust the smaller grains, while collecting these items almost three times as fast as the larger grains. The arboreal monkeys were less hesitant in going to the ground to retrieve food from the covered floor. The increased time spent foraging was at the expense of other behavior: aggression and abnormal behavior were reduced, but so were play and affiliative behavior, and so too was time inactive. Westergaard and Fragaszy (1985) also reported decreases in quiet social contact and proximity, and increased exploration, when a straw floorcovering was given to a group of capuchin monkeys. [Opportunity to forage also reduces abnormal behavior and increases activity in nonprimate species: chickens (Bareham 1972; Hughes 1976); pigs (Ekesbo 1981; Koomans 1981; Westergaard 1981); and cows (Albright 1982).]

The cost of this procedure was assessed in several ways. Woodchips reduced the time required for cleaning each enclosure from five hours per week to two hours. The enclosures, especially the walls and windows, were judged to be cleaner, and they were rated as smelling less after four weeks with woodchips than after one day with a bare floor that was cleaned daily with water, detergent, and disinfectant. To assess the potential for spread of disease by litter, samples of woodchips were removed periodically over eight weeks and either (a) tested for the presence of bacteria, or (b) inoculated with Salmonella bacteria and survival time of the latter measured. The results clearly showed that the longer the litter was in use, the greater was its bactericidal activity (also Turnbull & Snoyenbos 1973).

Conclusion

From these and other studies (e.g., Bloomstrand Alford & Maple 1987; Westergaard & Fragaszy 1985) one can recommend certain general techniques for enrichment in primates. One popular and successful approach employs food that is desirable, perhaps prized or rare (Feistner & Chamove 1986). To ensure adequate distribution, it should not be presented massed but widely distributed, and in such a way that animals can express at least part of their repertoire of gathering/extraction techniques. To reduce aggression, food is best chosen that naturally requires long
processing times, such as artichokes, *Aframomum*, nuts, millet, browse; or that has been modified so as to increase processing requirements, for example by freezing fruit, kibbling or grinding maize, or by hiding food in holes or under woodchips or straw. Any food-containing devices should be inexpensive and easily maintained and baited. Figure 5 illustrates such a device.

CONCLUDING REMARKS

We should continually be looking for ways to improve the treatment of animals in captivity. As far as nonhuman primates are concerned, the reduction of imports and the trend toward self-sustaining captive populations (Benirschke 1986) mean that many captive primates face a lifetime in conditions of spatial restriction. Research aimed at perfecting environmental conditions promises multiple benefits, including improved quality of the animals and even preparation for their eventual reintroduction to protected wild areas (Snowdon: in press). Considerate design of housing, paying attention to space, temperature, cover, etc, can to a large extent take care of an animal's physical comfort. Where compatibility can be achieved, social housing should be a priority, given the highly-evolved social potential of most primates, and the relative fragility of this potential in the face of restriction (Erwin & Deni 1979; McGrew 1981). Environmental enrichment is not a simple, all-or-none concept. The issues are complex and deserve dedicated consideration, as we have tried to convey in this chapter.

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Figure 5a. This chimpanzee uses an *Aframomum* stem with leaves intact (outlined in pen) to retrieve peanut kernels from a long distance (90cm). A pile of food (outlined in pen: bread, tomato, avocado, pineapple, mango, papaya) lies uneaten behind the chimpanzee.
Figure 5b. The chimpanzee uses the *Aframomum* stem with leaves intact to retrieve peanut kernels from an intermediate distance (60cm).
Figure 6. For close work (30cm), Mangustan strips off the leaves and uses the bare stem to guide the kernels through the obstacle of nails. Near retrievals took about 70 sec and far retrievals about 400 sec. Individuals spent about an hour a day working this simple, inexpensive, easily-baited device to obtain prized peanuts.
Environmental enrichment: A review

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SUMMARY
This review supports the idea that enrichment is an attempt to ameliorate problems caused by containment, that the goals of enrichment are to alter behaviour so that it is within the range of the animals' normal behaviour, and that evaluation of the success of enrichment techniques is important. I suggest that the idea of 'increasing psychological space' can act as a unifying concept for many of the techniques of enrichment, that is, many of the successful enrichment techniques act in a way similar to that of increasing physical space.

Recently there is increasing research interest in improving the welfare of captive animals, but there has been less interest in the rigorous operational definition of terms used in the description of environmental 'improvement' or enrichment, in evaluating the cost-effectiveness of enrichment, or in the development of theoretical models that guide research and integrate divergent studies. There are exceptions.18-32,33,48,89,111,138,148

The study of enrichment may be viewed as a conceptual extension of past research investigating the effects of early experience on the development of behaviour. And in these studies there are many suggestions about the directions in which enrichment research might fruitfully go. The use of deprivation or restriction was designed to answer questions such as: What is the role or importance of a given aspect (for instance, vision) in the expression of social interaction or in social development? In these studies, experimenters deliberately removed or restricted the variable in question; for example, by observing subjects during brief periods in the dark, either humans74 or monkeys,7,27 and by depriving animals for longer periods of sight11,122 or of particular types of visual input;132,135 and they observed blind humans naturally deprived of vision.68,90 In enrichment studies similar questions are addressed, but now by observing individuals in relatively impoverished environments and subsequently supplying the variable to the already deprived individual in order to assess its importance for behaviour. There are often two goals of enrichment studies: to improve the captive environment and to assess the importance of a given aspect for the animal's behaviour, both achieved by additions to an impoverished environment which is at present accepted as the norm.

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The aims of this contribution are to look at three areas which are addressed by enrichment studies, within the context of a review: (1) the problems produced by spatial restriction, (2) the goals of enrichment, and (3) the evaluation of enrichment techniques. I hope to put the first two of these into a conceptual framework to help guide future research.

PROBLEMS OF CONTAINMENT

The goals of enrichment may be difficult to achieve because of certain obstacles caused by the nature of containment. The basic problem is that caged animals cannot or do not carry out their normal range of behaviour.

Cage size

One fundamental reason that captive animals are behaviourally restricted is simply lack of space; the enclosure is too small. There is evidence that too small cage size is powerful enough to even inhibit that most robust measure of general well-being, namely that of reproduction.\(^{51,136}\) The mechanism for this inhibition is most likely to be the resulting adrenocortical stress response.\(^{92}\) Many behaviour patterns are influenced by cage size and its related variable of crowding\(^{1,8,45,56,93,136,145}\) and group size.\(^{30,77,110}\) Of course group size even has effects on behavior in the wild where spatial restrictions are less salient or even absent.\(^{71,97,101,106,137}\)

It is widely accepted that small cages increase the incidence of stereotyped movements and other non-locomotory abnormal behaviour.\(^{31,32,52,120}\) It is hard to imagine a case where simply increasing usable cage space would not constitute an enrichment procedure (but some disagree\(^{154}\)), even though additional increases of large enclosures might not dramatically change certain behaviour patterns, such as gross activity levels or inter-individual distance. It is likely that the ratio of benefit relative to cost would rapidly decrease after a critical cage size had been exceeded. The level at which increases in cage size would lead to substantial changes in behaviour could serve as an objective guide to minimal cage sizes for any given species. Of course these critical levels are different for different behaviour patterns.\(^{145}\) For example, one might expect activity stereotypes to disappear with a smaller increase in cage size than expected for exaggerated levels of aggression, for excess self-directed behaviour, and for behaviour caused by the absence of opportunities for foraging.\(^{36}\)

The literature on the effects of crowding\(^{8,36,48}\) shows that, surprisingly, it is the number of individuals in an enclosure which is the important variable and not the space available for each individual. Of course it is likely that this holds true only within certain limits; and in very large enclosures which are larger than the range of the animal or in very small enclosures where personal space is constantly violated (for example, battery cages), other mechanisms come into force.

While there are many questions about environmental enrichment with theoretical relevance, we can also ask at a predominantly practical level how we can improve enclosures.

Increasing psychological space

The problem with cage design is that it often does not make use of available space. Another way of counteracting deficiencies in cage size is by increasing the ‘psychological space’ of the enclosure. This can act as a unifying idea for many of the non-social techniques of enrichment.
To choose what aspects of the enclosure need to be changed to increase psychological space, one must understand what aspects of space are important to the animal in question. In other words, what do individuals do with additional space when they have it? They move through it, using it for various activities; they use the space to avoid other individuals and predators; they use it to look for food; et cetera. There are at least three ways to increase psychological space. The simplest is the better use of existing space such as walls, floors, ceilings, and of course the cage interior.

Walls
Related to the problem of cage size is that of cage design. Cages and enclosures are commonly designed by architects and their primary considerations are those of engineering, maintenance, cost, and human comfort. Bare, flat walls are easy to construct and to keep clean, but many animals cannot use flat walls. Often in zoos one sees primates housed in spacious cages, but in ones in which large open spaces go unused by the animals; and one problem of enrichment is how to use these valuable areas most efficiently. One recent study we have completed is illustrated in Figure 1. To assess the effects of vegetation on callitrichid monkey behaviour, climbing plants were grown on three types of trellis fixed about 10 cm from smooth walls. Plants grew best on the small-mesh flexible trellis, while monkeys spent most time on the large-mesh rigid trellis. The presence of plants had no measurable effect on monkey behaviour, but the presence of the trellises did enrich the environment by allowing the monkeys to make better use of the available space.

Floor
The floor is one area of the cage that which is often ill-designed or neglected. The floor and areas just above the floor are often kept clear for easy cleaning. In the large (27m³) enclosure that we use for callitrichid monkeys, the floor makes up about
40% of the total surface area that monkeys can use and as much as 66% of the horizontal surface area. In captivity these same monkeys almost never visit the floor (1% of the time) when it is bare but do so more frequently (15% of the time) when the ground is covered with some leaf-like substrate.\textsuperscript{110} In the wild these arboreal monkeys occasionally come to the ground to forage in the leaf litter or to cross open areas.\textsuperscript{85,116,141}

The effect with terrestrial monkeys is even more dramatic. In a zoo, groups of ground living primates (Lemur catta, Cercopithecus aethiops, Macaca arctoides) spent only about 15% of the day on the floor when it was bare and dirtied with faeces and urine as normal. When the floor was covered with woodchips, time spent on the floor increased to over 70%, a more appropriate use of the cage space\textsuperscript{6,30,34} and closely approximating the proportion of horizontal surface area it occupied in those cages and to wild patterns. Allowing domesticated animals the opportunity to forage has also led to reductions of abnormal behaviour and increases in activity levels (for example, chickens\textsuperscript{9,87} pigs,\textsuperscript{55,99,146} cows\textsuperscript{4}).

**Interior**

Yet another aspect of primate cage design which has been virtually ignored is that of what goes into the interior of the cage. In laboratories this area is often empty or has a simple metal shelf, but some researchers have systematically offered their macaques branches.\textsuperscript{123,125} With smaller monkeys the interior area may be filled with branches.\textsuperscript{38,62} One field study suggests that callitrichid monkeys primarily use horizontal branches, and they rarely (4%) move on vertical supports, mainly large tree trunks.\textsuperscript{72} Nevertheless, many of the cages used for these monkeys have only a few rigid horizontal branches with many thin flexible vertical branches hanging from them. Perhaps this is because it is easy to hang and replace these vertical clumps. Measurements in our colony indicate that about 25% of the branches are horizontal, 30% oblique, and about 45% vertical, with vertical branches much thinner than horizontal ones. In the wild, thin vertical branches are used almost exclusively for access to food, as illustrated in Figure 2. In the wild\textsuperscript{70} and in very large outdoor areas the monkeys spend most of their time (89%)\textsuperscript{40} in dense networks of thin, flexible, non-woody tangles. These are not normally found in captive situations.

We are currently looking at branch use and branch preferences in caged callitrichid monkeys.\textsuperscript{38} From our preliminary results it is clear that these monkeys prefer a large number of unevenly spaced branches; widely spaced supports are especially used by the more active juveniles and narrowly spaced ones by the less active adults. However, it is well known that the preference of animals is not necessarily in their best interest in captivity.\textsuperscript{2,23,46,47,53,54,87,88,109}

Another way to better use of existing space is by sharing space. This can be done by mixing species, by making use of their characteristic use of different areas and that they do not react to other species as they do to their own. Mixing species also enables two enclosures to be combined giving more space for each species.\textsuperscript{118,147} Ground living rodents eat fallen fruit in bird, bat, or primate exhibits in Edinburgh, Auckland, and Milwaukee Zoos. The presence of other animals also increases the complexity of the environment, although this aspect of enrichment has only been touched upon.\textsuperscript{96} C. cephus and C. nictitans are two monkey species often (80%) seen in polyspecific associations in the wild.
FIGURE 2 Hanging monkeys eating hanging fruit. Whole fruit in their skins were hung as they would be found in the wild. Bananas were quickly processed and eaten, but the skins of oranges had to be broken by humans before they could be eaten, and even then, took over 24 hours to be completely consumed.
While animals can share the same space at the same time, they can also share space sequentially. Techniques employing the rotation of animals are rarely reported. If animals are very active for only 50% of the day, they could be allocated an exercise area for half the day. For certain scent-marking animals, this may make the area more interesting, for others more threatening. Longer-term rotation is also a possibility with different species. If enclosure design permits, moving a carnivore from its enclosure would allow a herbivore access to an area with long grass and recovering saplings. It is difficult to understand why such a procedure is not regularly used in zoos.

**Dividing**

Dividing existing space is another technique of increasing psychological space. This technique seems especially effective in reducing aggression, probably because visual input is so important for that behaviour. Aggressive competition in the presence of food, commonly offered in only one or two discrete locations, may be increased over non-feeding conflict by a factor of 10 with a concomitant 50% increase in blood cortisol levels, suggesting considerable stress. Hiding food or making it more difficult to process by freezing it can reduce the competition.

The use of dividers can also require the animal to cover more distance when moving from one area to another. In a study just completed, we divided rectangular rodent cages into a maze using strips of plastic. Several developmental changes in the behaviour of the inhabitants resulted, especially an increase in activity and lower emotionality.

**Foraging**

One can increase psychological space both by encouraging animals to make more use of existing space and by changing existing space used. If individuals have to look for hidden food, then that space is changed in that it contains more bits of information, has more potentially relevant choices. The most effective technique so far developed is to encourage foraging by scattering small items of a desirable food into the floorcovering. Currently we are looking at other techniques for arboreal monkeys involving foraging in holes (see Figure 3).

**Learning**

Individuals perform various other activities in large spaces. They learn the characteristics of their environment to enable them to find food, to threaten and avoid conspecifics, and to flee from predators. They approach novel stimuli even though these are frightening, in order to learn about them. They seek out these challenges to reduce their fear of novelty in the future. If one of the activities that go on in large complicated spaces is that of learning, then we can set tasks that require learning and see if they serve as enrichment, and serve to increase psychological space. One way that we are experimenting with this is by making small, regular changes in the positions of branches in enclosures.
Environmental enrichment: A review

A bank of 80 holes of different sizes allowed tamarins to search for food. As they could not see the food, the probability of success only gradually reduced. Throughout the first hour after baiting, 30% of the group was on the apparatus at any one time.

FIGURE 3  A bank of 80 holes of different sizes allowed tamarins to search for food. As they could not see the food, the probability of success only gradually reduced. Throughout the first hour after baiting, 30% of the group was on the apparatus at any one time.
Energy
Calorie expenditure is another by-product of increasing space. Many of the tasks devised by Markowitz require subjects to walk or run from one operant device to another. There is evidence that caloric expenditure improves mood in humans, and it is likely that it will do so in caged animals when rigourously tested. One might expect it to be more important in those species which commonly expend more energy.

Variability
Increased space requires a corresponding increase in the variability of behaviour, therefore any increase in variability requirements or possibilities would be expected to act similar to increasing psychological space, and therefore be enriching. We are aware that different species are 'prepared' to do different things. Callitrichids use objects in their play, macaques also play with objects, capuchins also use tools, chimpanzees also make tools. When we gave tamarins a wheel device to run and play on, which had proved effective with macaques, they neither used it nor played with it (see Figure 4). When the preparedness of chimpanzees to make and use tools was challenged (see Figure 5), they extensively used the device they were given. Making ropes more variable and less predictable led to increased use.

FIGURE 4 A discarded bicycle wheel was covered with board and mounted so that it would easily spin for monkeys to play on. Cotton-top tamarins would only use it when it was baited with food. An animal used it a maximum of only 0.5% of the day.

GOALS OF ENRICHMENT
Two complementary short-term aims of enrichment studies are to increase 'desirable' behaviour and to reduce 'undesirable' behaviour. It is widely accepted that activities such as coprophagy, regurgitation, hair-pulling, self-injury, or stereotyped movements are undesirable. Conversely exploration, play, affiliation, and foraging
are commonly considered desirable. Other behaviour may be classed as one or the other depending on its frequency: withdrawal or avoidance, reproductive behaviour, aggression, inactivity, displacement, and feeding are desirable if moderate in frequency but usually undesirable if very frequent.\textsuperscript{14,35,78,79,126,142} For example, overeating, hyperaggression, and long periods of inactivity are believed to be indicative of poor health. Furthermore, an increase in desirable behaviour is usually believed to be associated with an improvement in physical or psychological health.\textsuperscript{67}

There are at least three approaches in assessing desirability of behaviour: normality, observer/caretaker acceptability, and theoretical considerations. Each may sometimes be conceived independently, but they are often related and lead to similar solutions. Probably the most common approach emphasizes normality: Behaviour which approximates that found in the wild is held to be desirable. In other words, behaviour should fall within the range of values for the form and frequency seen in the wild\textsuperscript{107} (but see Wemelsfelder\textsuperscript{148} p. 137). One problem of implementation is that the norms for many behaviour patterns vary, sometimes widely, with group size, habitat, season, and even from day to day with local weather conditions.\textsuperscript{41,83,117,129} If callitrichids rarely come to the ground in the wild, possibly because of predator pressure,\textsuperscript{85} is it normal/desirable that they do so in captivity and so better use the available space? It is not normal for animals to operate mechanical puzzles in the wild, but is it desirable for them to do so and thereby keep active in captivity? Sign language in the great apes is another example illustrating that enrichment does not necessarily directly lead to normal behaviour, although enrichment often leads to more normal levels of other behaviour patterns.

The second approach takes into account what is acceptable to keepers, technicians, and the public in zoos. The last is reported to like active and easily visible animals;\textsuperscript{142} but they do not like to see certain normal behaviour like mating, and dislike viewing certain abnormal behaviour patterns, such as regurgitation, reingestion, and coprophagy (shown by some captive gorillas\textsuperscript{5,72}). When manipulable floor-coverings with food-items led to increased activity in zoo-living orangutans, the exhibit was rated more favourable by visitors.\textsuperscript{142} The mismatch between the public preferring animals to be visible and the animals' possible preference to be hidden by foliage, can be reconciled by education.\textsuperscript{196}

\textbf{Theoretical}

The third approach is to choose enrichment goals because they are identified from a theoretical rationale. This rationale might be to occupy the animals, to exercise them, or to increase more normal behaviours. An example might be a goal of inducing more exercise or calorie expenditure for animals, based on their normal, free-ranging, or wild activity budgets (discussed in Chamo\textsuperscript{28}), or increasing problem solving opportunities, for example through burying food in woodchips,\textsuperscript{33} while taking into account feeding techniques in the wild. The use of swimming and fishing pools are other innovative examples requiring effort or skill by laboratory primates.\textsuperscript{75,96}

I have argued elsewhere\textsuperscript{112} that the goal of enrichment should be to allow and encourage animals to show behaviour patterns which are within the normal range of their wild counterparts. Others\textsuperscript{136} have suggested the goal should be to produce animals which could survive and reproduce if released into the wild.
Stress

The reduction of stress is another target of some enrichment studies. Poor cage design, cramped cages, crowding, et cetera are believed to stress animals, and as described above, a few studies have associated cage characteristics with physiological and behavioural measures of stress.\(^{16,43,51,61}\) I suggest that the problem actually is to achieve the optimal level of stress or arousal rather than just trying to reduce it to the lowest level possible. In the normal wild animal, the levels of arousal vary with the normal challenges of life (for example, Beuving\(^{13}\)). This suggests that any optimal level is (a) above zero, (b) is a variable one, and most importantly (c) that the duration of the peaks of arousal is brief.

The avoidance of stress illustrates that ‘stress’ has come to be viewed as equivalent to ‘distress’. Garmezy\(^{73}\) defines stress as ‘any action or situation that places special physical or psychological demands upon a person—anything that serves to unbalance an individual’s equilibrium or homeostasis’ (p.238). If stress is any event that destabilizes and taxes the system, then (a) positive events are also of interest, and (b) some stress is not necessarily undesirable. In this discussion I will use the term ‘arousal’ to refer to the consequences of both positive and negative events, and ‘stress’ to refer to the long-term consequences of negative events.

Both the human and animal literature suggest that levels of stress or arousal which are markedly and persistently lower than those likely to be found in the wild lead to individuals who do not adapt well to subsequent stressors or adapt well even in the absence of identified external stressors. They over-react both in intensity and duration to mild stimuli and stressors (for example, \(^{49,142}\)). It appears as though they have difficulty inhibiting a response once a response has become probable.\(^{26,133}\) Some stress early in life appears to help individuals to cope with stressors when they are older.\(^{19,24,49,50,63,67}\) Also adult animals appear to seek challenge when living in captivity.\(^{5,22,81,84,91,94,103,104,105,110,115,119,150}\) A growing number of studies have shown that animals may choose to work for food despite the free availability of the same food. We are currently trying to determine why callitrichid monkeys select peanuts in their shells (80% of choices) to those already shelled even though the former take more effort.

We have just completed a study which strongly suggests that brief arousal is beneficial to animals living in the constant conditions of a laboratory. During days on which occurred arousal caused by the normal husbandry procedures of capture of infants or adults, or when large bird-like silhouettes passed over the enclosures, we found that monkeys’ behaviour was more like that seen in enrichment studies than that seen in long-term stress studies.\(^{113}\) This similarity was less evident in the morning evaluation taken immediately after the arousal than in the afternoon. The data is presented in Table 1 and shows that six behaviour patterns (in bold) can be used to differentiate beneficial effects of enrichment from those of long-term stress.

One abnormal behaviour which appears to be a good indicator of a poor environment is stereotypy. It is often suggested that the presence of repetitive stereotyped movements ‘can be seen as the animal’s attempt to increase its sensory input’ \(^{8,53,148}\) (p.143). ‘To increase sensory input’ implies an existing low level of input which needs to be increased in either the amplitude of stimulation, an increase in the variability of stimulation, or a change in the particular stimulation being experienced.
Stereotyped movements appear to occur when there is some arousal or stress. This may be due to boredom, frustration, fear, or merely stimulus change.\textsuperscript{12,31,36,120} It seems more likely that stereotyped movements are habitual patterns of stimulation which, because of their familiarity and repetitive nature, are calming to the individual. Stereotyped behaviour is followed by lower adrenocortical levels.\textsuperscript{5,14,45} The patterns are developed through long periods of deprivation or restriction and are therefore resistant to change (discussed elsewhere\textsuperscript{6}). The reduction of stereotypy is a sensitive measure of enrichment.\textsuperscript{21}

Table 1
Significant changes (non-significant changes are in brackets) from baseline in behaviour from five studies of enrichment, from the present study, and from three studies involving stress.

<table>
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<th>ENRICHMENT</th>
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<th>STRESS</th>
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<td><strong>SPACING</strong></td>
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<td><strong>PLAY</strong></td>
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<td>+ (+)</td>
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<td><strong>INACTIVITY</strong></td>
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<td><strong>SCRATCH</strong></td>
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</table>

+ indicates an increase from baseline, – a decrease, = no change. \textsuperscript{a} Play results are for juveniles and sub-adults who play the most; adults showed the opposite effects. The 4 numbered studies in larger bold type-face all used callitrichid monkeys like the present study.

(1) Boccia, 1989;\textsuperscript{17} (2) Westergaard & Fragaqy, 1985;\textsuperscript{149} (3) McKenzie et al., 1986\textsuperscript{109} (4) Chamove et al., 1982;\textsuperscript{34} (5) Anderson & Chamove, 1984;\textsuperscript{6} (6) Glatston et al., 1984;\textsuperscript{76} (7) Chamove et al., 1988;\textsuperscript{39} (8) Worsley-White, 1988.\textsuperscript{152}

Range of behaviour
Cages also function to limit the range of behaviour shown by an animal. Several lines of research have shown that increasing the range of foods eaten is more healthy,\textsuperscript{98} increasing the range of muscles used is healthier,\textsuperscript{144} and increasing the range of stimuli to which one is exposed is healthier\textsuperscript{16,55,67,80,55,113,127,130} and less boring.\textsuperscript{146} Consequently, enrichment studies can try to increase the range of behaviour expressed\textsuperscript{89} while increasing the range of stimulation available.\textsuperscript{121}

The most obvious of these behaviours, and considered by some to be the most important\textsuperscript{69,119} is the opportunity to move and forage. Primates spend between 25\% and 90\% (mode = 55\%) of their day searching for and processing food.\textsuperscript{44} Even in large semi-natural enclosures where monkeys are given food in excess of their needs, mandrills still spend 45\% of the day foraging (Feistner, pers. com., 2/88). In cages this is dramatically reduced, to about 4\% in callitrichids (personal data), 5% in chimpanzees and gorillas,\textsuperscript{16,79} and to 6\% in macaques.\textsuperscript{6,17} Techniques to increase the search or processing time can increase this to around 10\%, 20\%, and 30\% respectively.
Other attempts to encourage foraging have not been as successful. Nash\textsuperscript{14} evaluated an artificial termite mound where chimpanzees could fish for mashed banana. The nine 'fishin' chimps' spent an average of only 2 minutes per day at the mound, and the most interested individual only spent 4.2 minutes per day at the mound. 3 minutes of which involved preparing tools and dipping. However, they were involved in an activity that otherwise they would not show. A similar device with orangutans\textsuperscript{15} has proved more successful increasing foraging time to 47\%. We modified the device making it less expensive to construct and less time consuming to bait\textsuperscript{29} (Figure 5).

\textbf{FIGURE 5} To retrieve peanut kernels, this chimpanzee uses an Aframomum stem with leaves for long distance (90 cm) and intermediate distance (60 cm) retrieval (lying to his right); for close work (30 cm) Mangustan uses a stem stripped of leaves to guide the nuts through the obstacle of nails. Short retrievals took about 70 sec and long retrievals about 400 sec. Individuals would spend about an hour a day working on this simple, inexpensive, easily baited device to obtain prized nuts. A pile of food lies uneaten behind him (bread, tomato, avocado, pineapple, mango, papaya).
Without the opportunity to search for and process food, certain animals continue to perform quite normally—like hamsters piling food; some perform behaviour in inappropriate ways—like raccoons washing food in their water dish or stereotyped pacing;\(^67\) some perform food-related behaviour in detrimental ways—like regurgitation and coprophagy in primates.\(^79\)

It seems that animals use abnormal behaviour to improve their condition. In pigs housed in stalls or kept in tethers, stereotypies can occupy as much as 60% of the day.\(^14\) The ability of stereotyped behaviour to lower adrenocortical levels suggests that stereotypy is stress reducing. In very simple enclosures it may also be impossible to perform certain behaviour at all, like dust bathing in chickens,\(^53,87\) wood gouging for gum in marmosets,\(^40,108\) and indeed foraging in most primates.\(^131,152\)

There are those who will argue that because a stereotypy is an adaptation to an abnormal condition, that it is somehow beneficial and therefore good. This argument seems to be fallacious, like arguing that the fever following infection is good in itself and not merely beneficial during a brief period of abnormal challenge.

**Control**

Cages are believed to reduce the degree of control that individuals have. When rooms are visually divided, male macaques cannot control female aggression and aggression can increase.\(^59,60\) This change in behaviour after the imposition of dividers does not happen in stable callitrichid monkey groups\(^109\) or in stable macaque groups.\(^59\)

Reduction of control by being in cages is also exemplified by the effects of visitors on the behaviour of zoo animals.\(^28,76,96,152\) One can view zoo visitors as a stimulus in an otherwise barren environment, and certainly some primates interact with visitors. An alternative to viewing visitors as a beneficial stimulus, supported by an increasing amount of evidence,\(^28\) is that visitors change the behaviour of monkeys in a way similar to that caused by other stressors (see Table 1). The data suggest that the greater the number of visitors, the more behaviour is changed; noisy and active visitors cause more change; and visitors located at a level above monkeys cause more change than those at a lower level. This research suggests the importance of refuges for the animals, to let them control access to and by visitors.\(^1,66,100\)

Other evidence for the importance of control is the surprising preference animals have for working for part of their food in the presence of free food (previous references).

There is currently discussion on the importance of control in the psychological health of both animals and humans. It is clear that in the wild, animals have more control over certain stimulus variables and over most response variables in comparison with animals in captivity. Such control is restricted in cages, particularly approach and withdrawal responses with respect to stimuli outside cages, withdrawal responses to stimuli within cages, and the opportunity to produce effective motor responses. The discrepancies between control of stimulus and response variables in the captive versus natural environment may be an important idea underlying enrichment studies.
A study to assess directly the effects of early control over the environmental events on socioemotional development showed that young rhesus monkeys that could work in order to receive food and water, showed less self-directed behaviour and were more exploratory than monkeys receiving the same rewards independent of their behaviour. Thus in order to produce behaviourally competent individuals, one could argue that animals should be allowed to execute motor acts on their environment which have relevant consequences. Extreme loss of control leads to syndromes such as ‘learned helplessness’ and to individuals that use their own body to modulate their emotional states.

Where animals do have a type of control, the opportunity to withdraw (for example, from predators) means that for the wild animal, the period of arousal is usually brief; in captivity this is not the case (for example, in zoos). Even when stressors are prolonged, the wild individual has options. From personal observations, it seems likely that in many cercopithecus species it is stressful for young adult males to remain in their natal group, as evidenced by a slowing of growth and development. When they withdraw or are withdrawn, one can see a marked growth spurt.

**Complexity/predictability**

On a more conceptual level, many cage environments can be thought of as reducing the complexity and increasing the predictability of stimulation. In a predator-free or predator-predictable environment (such as, laboratory or zoo) or in an environment where only one type of food is offered, decisions are more simple, alternatives fewer, stimuli more repetitive and predictable.

**EVALUATION OF SUCCESS OF ENRICHMENT**

Assessment should be seen as crucial in studies of the effects of enrichment, since it answers the questions—Does the manipulation/enrichment do what it is designed to do? Are the effects reliable? And does it do it well enough to be worth the effort, that is, does the benefit exceed the total cost?

The cost is most often viewed in terms of time or money, but can also be measured in terms of alternatives. If one form of enrichment is chosen, then other potential forms may have to be excluded. If a ball or branch is chosen as the enrichment device (for example, 128), then this may be at the expense of other possible devices. The cost in baiting time of the tree stumps shown in Figure 6 was so great that the device will not be used despite having some benefits. One can view the evaluation of an enrichment technique along similar lines to that of a new drug. If it is the first useful drug, then the drug is compared with that of a placebo, unless its benefits are so valuable or so obviously above that of known placebo effects to make such a trial unnecessary (for example, vaccination for smallpox). If it is an improved drug, then it is compared with previous drugs used for that illness.
FIGURE 6 Holes were drilled into a large log that was mounted vertically. When peanuts and raisins were pushed into the holes, tamarins would gouge them out. The apparatus encouraged the monkeys to adopt a gripping posture reported from the wild but not usually seen in captivity. Individuals also used the top of the log to avoid the proximity of other animals.
Just as cost can be measured from several aspects, so can benefit. Both the short- and long-term effects of an intervention need to be measured and criteria for the duration of the effect need to be specified. For example, a small controlled fire in a large enclosure for chimpanzees led to a dramatic change in behaviour for a short period of time during the first presentation; but interest was not maintained after the second session and the fire was not used as a basis for tool use. It is usually long-term changes in behaviour that are of interest and measured in competent studies of enrichment (for example, 149). Changes in behaviour usually need to occur frequently during the day, and they need to be maintained over long periods of time to be considered effective and worthwhile.

Finally, to measure benefit one needs to decide the importance of behaviour which is altered. Two extremes will illustrate the difficulty in such a decision. Certain behaviour may be considered important because it normally occurs frequently, such as foraging, locomotion, or huddling. King and Norwood consider the opportunity to leap to be important in squirrel monkeys, as over 40% of their travel is accomplished by leaping. Other behaviour which may be considered important precisely because it normally occurs infrequently (see Figures 5 and 6). Dust bathing in fowl is an example of food-offering and sharing in tamarins. And still other behaviour which may be important, is infrequent behaviour which when used may actually lead to the reduction of more common behaviour. For example allowing the use of tools enables capuchin monkeys to process certain nuts four times as rapidly as without tools while the range of their behaviour increases.

As an example of these principles of assessment, between 1979 and 1986 a series of studies assessed the effects of covering the floor with a deep, absorbent litter in the large cages of eight different primate species. The goal was to improve welfare, especially to increase activity (discussed later) and reduce abnormal and undesirable behaviour shown in some of these species.

The technique of enrichment used a 4 cm-deep floor-covering of woodchips with small items of prized food mixed into it. The choice of floor-covering was not one of emulation—to copy nature, as this is impractical for almost all captive environments; rather the aim was simulation—to provide certain, possibly critical, components of the natural environment.

The success of the technique was measured over several months to determine costs and benefits and the stability of the behavioural changes. Technician workload was assessed, cage cleanliness and odour were evaluated, and changes in the animals' behaviour was recorded. Bacterial vigour in the woodchips was also measured to evaluate health implications. Finally a hypothesis was tested—that enrichment would be more effective when targeting behaviour more common to the animal in its natural setting. Therefore it was predicted (1) that changing the opportunity for an important and common behaviour pattern like foraging would lead to substantial changes; and (2) that arboreal species would be less affected by providing a floor-covering than would more terrestrial species, since the former are less likely to spend time foraging at ground level.
Environmental enrichment: A review

The results of these studies clearly showed the high cost-effectiveness of the floor-covering in improving behaviour. The desired goals were achieved in the initial studies on stump-tail macaques; self-injurious behaviour was reduced by more than half: aggression was reduced by a factor of 2 in adults and by a factor of 10. Similar reductions occurred in all but one of the eight species subsequently studied and in which aggression was seen.

When the floor of the cage or enclosure was bare, not surprisingly macaques spent almost no time searching for food items on it. When the floor was covered with woodchips only, the animals spent about 5% of their waking time searching through this floor-covering. When grain was added to the woodchips, the monkeys' searching increased to almost 15% of their waking time, even when grain was also freely available elsewhere. When free grain was removed so that the only grain available had to be found and extracted from the woodchips, the monkeys spent over 30% of their day foraging. This percentage more closely resembles the behaviour of freeranging macaques.

All the eight primate species assessed have shown increased use of the floor area when it was covered with woodchips. We were surprised to find no support for our prediction that arboreal primates would benefit less from the floor-covering: all groups showed increases in floor use. The increased time spent foraging was at the expense of other behaviour: Aggression and abnormal behaviour were reduced, as was the amount of time spent inactive, and so also were play and affiliative behaviour but to a lesser extent.

The cost of this procedure was assessed in several ways. The time required for cleaning was reduced from 5 to 2 hours per week per enclosure when woodchips were used. The enclosures, especially the walls and windows, were judged to be cleaner, and they were rated as smelling less after four weeks with woodchips than after one day with a bare floor cleaned with water, detergent, and disinfectant. To assess the potential for the spread of disease when using the litter, samples of woodchips were removed periodically over eight weeks and either (a) tested for the presence of bacteria, or (b) inoculated with Salmonella bacteria and its survival time measured. Similar to tests using chickens, the results showed that the longer the litter was in use, the more inhibitory it was to bacterial survival.

Two studies illustrate the complexity of proper evaluation of enrichment procedures. Rosenblum and Smiley found that providing a foraging task reduced behaviour such as self-aggression and abnormal posturing in high- and low-ranking members of a group of isolation-reared bonnet macaques, but these behaviour patterns increased in intermediate-ranking monkeys. Bloomstrand et al. reported behavioural deterioration in certain members of a chimpanzee group with access to a food puzzle, while other members' improved (also ). It seems likely that such negative reactions arise from social tensions created by the competitive nature of these two enrichment tasks. In the wild it is uncommon for animals to be competing for food massed into a small area. Consequently, it might be suggested that either such enrichment devices are particularly suited to individually-housed animals, or that several devices be offered to the group simultaneously.
Although concentrating on cage size and design in this review, these are not the only problems to be confronted by those desiring enrichment. Providing social interaction for a social species seems very important to social humans. There are many studies which have looked at this problem in pair- and individually-housed monkeys, and in infants and adults. The abnormal behaviour patterns caused by social deprivation or restriction are no less dramatic or salient, and social primates seem strongly motivated to maintain physical social contact (Figure 7).

**FIGURE 7** When two adult male stumptailed macaques were temporarily separated by a clear perspex partition, they tried to maintain physical contact.

**Acknowledgements**

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Environmental enrichment: A review


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Enrichment—past and future

While the literature pertaining to environmental enrichment would be familiar to many involved in the maintenance of animals, few are conversant with the large number of studies published prior to the popularisation of the term 'enrichment'. Although comprehensive reviews of enrichment commonly begin their citations around 1987 (e.g. USDA, 1992), the publication of Markowitz' book in 1982 is most often cited as heralding the introduction of the concept. Although we began a series of studies several years earlier (Chamove and Anderson, 1979; Chamove et al., 1982), it was not until the early 1980s that the term began to be used. Work relevant to this concept, rarely cited in current work, was being done as early as the 1960s (e.g. Kuo, 1967; Kerr et al., 1969), but with a different focus.

Current environmental enrichment research is directed towards how best, or most efficiently, to improve the environment of captive animals. The application of this ideal often necessitates a change in focus to address what is the minimal condition for the production of normal behaviour. If an orang-utan is immobile for most of the day, a polar bear wearing a track in the concrete through repetitive pacing, or a group of bulls showing damaging levels of aggression, it is necessary to ascertain what is the least one can do to reduce or eliminate the abnormal behaviour observed. For it is the presence of abnormal behaviour that often signals the need for improvement in housing.

Psychological research into animal social behaviour in the 1960s and 1970s was largely concerned with the extrapolation of the mechanisms responsible for the development and expression of normal behaviour patterns. For example, the research of Kuo (1967) to determine which early experiences lead some cats into becoming rat-killers and others not, is relevant to a diversity of enrichment problems. These problems include the housing of different species together; for example, dogs reared with sheep as protection against wolves, mixed species on farms for improved grazing (Chamove et al., 1993), or to resocialize animals that have been isolated for long periods of time.

The recognition that monkeys reared in single cages were abnormal in the quality and quantity of certain behaviour patterns, led to extensive research concerning the precursors of normal maternal, aggressive, and sexual behaviour patterns. In the 1960s I was a student in a laboratory which needed to separate infant monkeys from their mothers, which had contracted diseases from their human captors in Asia. Much of my early research was designed to ascertain whether contact with other infant monkeys could compensate for the lack of mothering, and the quantification of the minimal contact with other infants needed (Chamove, 1973; 1978).

These studies are important for the establishment of guide-lines concerning matters such as the separation of, for example, primates. In this specific case, the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes (NHMRC, 1990) prescribes keeping animals in environmental conditions which suit the behavioural needs of the animal. But how can this recommendation be implemented in the case of a monkey which would normally never be out of sight or potential contact with other monkeys? The common recommendation is to prohibit forced separation. But research suggests that for older monkeys of an age when they are no longer protected by infantile characteristics from the aggression of others, single separations of under a week, or repeated separations of less than four hours are without measurable detrimental effects. In fact they can have some positive effects. In addition, for monkeys that cannot be housed for the majority of the time with other monkeys, two hours a day of contact is sufficient to eliminate most abnormal behaviour in most species.

There are a number of other issues extensively researched prior to the 1980s which are relevant to enrichment. Spacing, group size and density, exploration/curiosity, and sensitive periods are a few of these (see Hinde, 1966). Animals need to know the precise layout of escape routes. Very slight changes to significant paths involve animals in relearning these routes, occupying their time in an otherwise boring, predictable, and non-challenging environment (Chamove, in press).

The future

There are currently a number of studies in progress, examining the effects of a wide range of enrichment techniques and devices. The prospective direction for enrichment will be increasingly influenced by theoretical considerations. It is apparent that in order for the concept of enrichment to develop into more than simply a descriptive term, there are a number of questions incorporating difficult theoretical principles that need to be addressed.

How does one know if one is enriching an animal's environment? If a rubber ball is placed in an animal's enclosure and the animal plays with it for, say, 11 minutes and ignores it thereafter, is this enrichment? Without any consideration of the issues, it appears that the 11 minute rubber ball is certainly enriching. But the definition of enrichment is critical in this case. It is widely accepted that the benchmark for enrichment is the return to normal (wild) behaviour.

By this is meant:

• the normal frequency and pattern of, or the normal quality and quantity of a behaviour pattern.

If wild animals in their natural environment normally spend between 40% and 70% of the day foraging for food, this percentage of foraging time should be the goal for enrichment. It is not normal for animals to play with balls in the wild, but it is normal for them to play. Eleven minutes is far lower than normal play levels but higher than zero.

The institution of normal behaviour as a goal can also lead to some problems. Three examples are given to illustrate this.

• If marmosets and tamarins are provided with a balanced and nourishing diet, presumably atypical of that encountered in the wild, they often produce triplets rather than twins. These animals are only able to rear twins, and if intervention or hand rearing (with its inherent problems such as difficulties of subsequent resocialisation) is decided against, one triplet will be become weaker and finally die from starvation.

• The minimisation of stress in captive animals is universally advocated. But in the wild, animals not only frequently encounter stress, but in a number of instances regularly appear to actively seek out such situations. Monkeys patrol the boundaries of their territories two or three times a week and engage in exciting vocal and physical displays. If it is intended that animals in captivity be allowed to express normal behaviour patterns, it may be necessary to introduce simulated stressors to
The time needed is considerable considering they question qualitative has been with wild technique enrichment of rubber. Determining the environmental for in even seems an introduction of the 11 minute from a the difficult in the phenomenon, which 1989). Normal mother-rearing produces more aggressive animals, while rearing only with peers produces abnormally low levels of aggression. Such animals will form compatible groups in captive situations. Which is the more desirable outcome in the captive situation — docile, compatible monkey groups or normally aggressive ones?

To evaluate a particular enrichment technique, another question to be should be whether the enrichment technique is cost-effective. Is the construction of elaborate artificial termite mounds and the considerable time needed to bait them with honey every day, justified considering they are used for less than three minutes a day by chimpanzees (Nash, 1982)? The keepers at Edinburgh Zoo did not think so and this procedure has been abandoned.

Associated with this question is the qualitative question of how to measure the effectiveness of any enrichment technique. Foraging is a common event in the wild and tool-use a rare event. Are they to be valued equally when determining the allocation of enrichment resources? Is doubling foraging time equal to doubling tool-use time?

Does the introduction of the 11 minute rubber ball lead to more normal behaviour, and is it cost effective? What seems an obvious and inexpensive enrichment technique may not be worth even the minimal time and effort involved in its implementation if one sets criteria for environmental enrichment.

How to define and evaluate enrichment and behaviour change requires the imagination and ingenuity of those from a diversity of disciplines in (Chamove, 1989). If such issues are addressed, which essentially involves further elaboration and quantification of this difficult phenomenon, the result will be a more systematic and organized investigation of environmental enrichment in the future.

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References

Orbital puncture

The orbital puncture method is commonly used to obtain blood from rodents. The authors of this short paper (Van Herck et al., 1992, from the State University, Utrecht, the Netherlands), conducted a survey of laboratory animal welfare officers in the Netherlands, where (as in other countries) there is considerable controversy and concern about this technique.

In the Netherlands, about 1.1 million vertebrate animals are used per year for scientific purposes and about 45,000 orbital punctures are performed each year. This is done only in the smaller rodents, such as mouse, rat, hamster and guinea pig. Ether is the most commonly used anaesthetic. Complications were noted in about two-thirds of the institutes where this technique is performed and blindness occurred in 1-5% of animals subjected to it. References to the various forms of complications are cited.

The authors conclude that in more than half the institutes where orbital puncture is performed there are objections to it, which are essentially of an emotional or ethical nature.

A further study by Van Herck and colleagues (1992) examined the histological changes in the intra-orbital tissues caused by this technique of blood sampling. Orbital puncture caused haemorrhages in the puncture track and, depending on the technique used, also in the periosteum. Four days after puncture, inflammatory reactions were present in the puncture track. Depending on the technique of puncture these reactions were also seen in the eye muscles and periosteum or in the Harderian gland.

Within four weeks after puncture, the lesions had healed without detectable scars.

References
Part 2: Enrichment--Non-Social


Woodchip litter in macaque groups

A. S. Chamove, BA, MA, MiBiol. and J. R. Anderson, BSc.

SUMMARY

The effects of the presence of woodchips as a floor covering were assessed in two pens housing 28 monkeys. No negative effects were found, while aggression decreased and time foraging on the floor increased. The chips were less expensive, they reduced odour, and the animals appeared more well-adjusted than with no floor covering.

INTRODUCTION

In the wild, non-human primates spend a high proportion of time searching for small food items. When captive, however, our concern with health and hygiene obviates these behaviours. Most authorities recommend that excreta be removed from cages at least once daily whether or not the animals can contact the excreta. This usually results in the recommendation that enclosures or cages be designed so as to be maximally cleanable, and if litter is used, it be restricted to the cleaning tray below mesh floors. The rare advocacy of litter with primates is most sensibly illustrated as follows:

“If litter or bedding is used in animal cages or pens, it should be changed as often as necessary to keep the animals dry and clean, and to minimise offensive odours” (p. 6).

With primates, they continue, daily cleaning may be necessary. Nevertheless, and against all of this advice, we chose to evaluate woodchips as a long-term deep litter for macaques. We felt one should evaluate the effects on psychological well-being: giving the animals something to occupy their time, giving them something they do naturally such as searching through and manipulating the litter; physical well-being: fighting, food distribution, cleanliness, dryness, disease transmission, noise reduction, and cold surfaces; economy; and aesthetics: odour, visibility of animals, social behaviour and appearance of the animals. It was felt that deep litter might affect all of these aspects of laboratory primate maintenance.

METHODS

Two groups of stump-tailed macaques (Macaca arctoides) were used. The Juvenile group consisted of 15 laboratory-born monkeys, five of which were males, and...
averaging 4-6 years of age. The three youngest members had been living in this pen group for 5 months, all others for at least 15 months. All of these subjects had been separated from their mothers in the first week of life, reared in individual cages (as described by Chamove 5 6), but (all except three) had experienced daily social interaction with a minimum of three other monkeys. From this we can expect social behaviour approximating that of normal monkeys.6

The Adult group consisted of 13 monkeys, 10 adult feral animals and 2 juveniles and one infant born and reared in the group by their mothers. Additional information on living conditions and social behaviour of these monkeys may be found elsewhere.7

Six monkeys from each group were chosen as subjects. The two most dominant, two most subordinate, and two intermediate group members were selected on the basis of dominance tests.8 One of each of the dominant pairs, one subordinate from the juvenile group, and one intermediate from the adult group were males; all others were female.

The animals were housed in indoor-outdoor areas composed of approximately the following; 6.7m² of indoor caging with a grid floor and 14m² of outdoor floor space with solid floors; The roof of the outdoor pen area was covered with mesh open to the sky but half of the area had been subsequently covered with clear plastic sheeting which drained into the living area. The outdoor pens were 3.7m high. Several ledges, bars and platforms provided a variety of outdoor elevated locations on which the monkeys could rest or travel. During the Woodchip conditions, 120Kg of woodchips were spread on the floor of each outside pen. No subsequent attention was paid to the woodchips. In the bare condition, the floor of the outdoor pens consisted only of bare, solid asbestos tiles which were cleaned daily in the morning by technicians using water and Tego.

Behaviours were recorded on to check sheets following two formats. The first, concerned with feeding behaviour, was designed to accommodate information on the rate of feeding of individual animals and on the number of animals on the ground at minute-long intervals. The second was concerned with 14 categories of social behaviour, 4 nonsocial behaviours, and the location of subjects. The behaviours recorded were as follows: huddle, groom, contact, play, proximity, sex, displace, threaten, chase, fight, be displaced, submit, flee, be attacked, walk, object manipulate, sit, and visual explore. The social categories were combined in such a way as to provide two primary measures: positive social interaction consisting of the first 6 behaviours, and negative social interaction of the second 8 behaviours. Walk and object manipulate, provided a composite index of nonsocial active behaviour, while sit and visual explore, represented a measure of nonsocial passive behaviour.

The following four conditions were of interest: Social behaviour in a bare pen with no food; social behaviour in a woodchip-covered pen with no food; social behaviour in a woodchip-covered pen with grain; feeding behaviour in a woodchip pen with grain in the litter.

Four days of social behaviour testing were carried out in each of the two no-food conditions. Six monkeys were observed for a total of 20 minutes each, at 5 minutes per day giving a total of 120 minutes of observation per group for each condition. Data were collected in the form of modified frequencies using intervals of 15 seconds. If a behaviour occurred during this interval a score of one was
recorded. These observations were carried out between 1300 and 1500 hours.

Feeding behaviours, testing in both grain conditions, consisted of four days of testing. On the first day 340 gm of dried maize (average diameter=8.3 mm) was scattered in the pen. If woodchips were present, the chips were then raked briefly to bury most of the grain. Each animal was observed for six one-minute long periods and the number of times any food items were transferred to the mouth recorded on a hand tally. At the end of every minute, the total number of animals from the group that were on the ground were noted. On the second day the same weight of pigeon food (diameter 7.6 mm) was similarly used. On the third day a mixed grain composed of 12% barley (diameter 4.7), 27% milo (2.6), 16% white dari (3.7), 22% wheat (4.6), 19% sunflower (4.9), 2% maples (7.2), and 1% maize (8.3), by number was used for testing. The fourth day’s grain was white millet (diameter 1.6). As the grains differed in size, the number of individual items in a fixed weight was computed for the different grains. One hundred gm. of the above four grains were estimated to contain 340, 370, 4500 and 20 250 individual grains respectively.

An analysis of the cost of woodchips was undertaken as well as the smell of new condition. A new employee was asked to rate the two pens daily on a scale of from 0-4: none, slight, moderate, strong, or very strong smell respectively.

This was done for four weeks with no woodchips in either pens and then for four weeks with woodchips but no other cleaning in one pen and normal cleaning but no deep litter floor covering in the other. At irregular intervals other individuals were asked for ratings of the two pens.

Analyses of variance were used to assess the results. Alpha was set at 0.05. Analyses used three levels of dominance and two different pens as between subjects variables, and the presence or absence of chips as one of the repeated measures. One analysis tested time on the ground outside versus time spent above the ground outside; one analysis tested positive versus negative social behaviours; one tested nonsocial behaviours; one tested aggressive behaviour when given grain; one tested numbers of animals on the ground when given grain; and finally the rate of hand to mouth contacts, as a measure of the rate of grain consumption, was likewise tested. Data were also collected in the evening after feeding for the juvenile group, and these were tested against the afternoon observations.

RESULTS

In general the results showed that aggression was reduced in the presence of chips when grain was scattered; and after 6 weeks the chips smelled less than the bare pen after 24 hours.

When the four grains were offered aggressive behaviour was 4-6 times more frequent when the floor was bare as compared to with chips (F=27.0, df=1, 6, p=0.02). This chips effect also interacted significantly with pen location (F=12.7, df=1, 6, p=0.01). The frequency of aggression was 10 times greater for the pen containing the 15 juveniles and 1.8 times greater for the adult pen. There was no interaction with grain type/size although it appeared that the smaller grains were correlated with less aggression.

The analysis for positive and negative behaviours with no grain showed no significant effects related to the chips. There was a tendency, however, for positive
behaviours to increase slightly and negative behaviours decreased by a factor of ten in the presence of the chips (F=3.7, df=1, 6, p=.10). The increase of positive behaviours was due to the subordinate monkeys, the decrease of negative behaviours was seen in all three ranks but was especially marked in the subordinate animals.

There were no significant effects in the analysis of time on the ground when given grain. There was a tendency to spend slightly more time on the ground with chips present (mean=30.6 versus 27.2 sec.) than when bare, and the animals were longer on the bare ground with smaller, and therefore more numerous, grains.

The analysis of location of monkeys without grain present gave no significant effects of the presence of clean chips. In fact the animals spent slightly less time outside when chips were present and a slightly less percentage of that time on the floor (F=1.2, df=1, 6, p=.31).

The analysis of nonsocial behaviours showed no significant effects of the presence or absence of chips. The amount of active nonsocial behaviours was increased threefold in the absence of chips, but this was not significant (F=1.1, df=1, 6, p=.33).

---

**Figure 1.**

Hand to mouth contacts for animals of three different dominance positions. Note that each block is six minutes after the preceding block.
The analysis of hand to mouth contacts showed the most significant effects. There were significant differences in the following: Litter, grain, blocks, blocks x rank, blocks x rank x pen, litter x blocks, litter x blocks x rank, litter x blocks x pen, and litter x blocks x rank x pen (F=5.0, df=10, 30, p=.0003). Figure one illustrates these effects. Dominant animals feed faster at first and all animals feed faster in the bare pen. The difference in feeding rate is greatly reduced in the presence of chips. The interaction with pen is explained by the observation that the Juvenile subordinate monkeys did not show a peak of response during blocks 2, 3 and 4 in the bare condition. The more aggressive Juvenile animals inhibited foraging in the more subordinate members of the group. Also of interest was the significant grain effect; the smaller the grain size, the greater the number of hand to mouth contacts. The mixed grain and the millet showed over two and three times the number of hand-mouth contacts respectively as did maize, although millet was hardly eaten at all when it was raked into the wood chips, possibly because it could not be seen.

When the juvenile pen was treated in the evening, there was no effect of chips. During the evening testing there was less positive behaviour and much more negative behaviour than during the afternoon (F=16.9, df=1, 3, p=.02). While the presence of chips reduced aggression by 2.5 times, this effect was not significant (F=.17, df=1, 3, p=.71).

Cleaning two pens every other day took one man 5 hours per week when no woodchips were present. Cleaning with woodchips took one man a total of 8.5 hours every four weeks. This included removal of the chips and cleaning the pen once in four weeks (3.5 hrs) and daily sweeping of the corridor when chips were tracked about by persons leaving the pens (1.5 hrs). The chips cost £2 per 40Kg bale.

The data on the amount of monkey smell from the pens shows that woodchips cleaned a minimum of every four weeks is less objectionable than a bare pen cleaned every other day. The average rating for the bare pen was 1.02, slight; the average rating for the pen with chips was 0.58, between none and slight. The bare pen received five strong and five moderate ratings whereas the highest rating of the chip pen was a single moderate rating. Two pens were left six weeks and still naive raters not working with animals of any kind could only detect the smell of the wood chips and no smell of faeces or urine.

DISCUSSION

This brief study has shown that the presence of woodchips on the floor of a living pen has no detrimental effects and has several beneficial ones. These are the reduction of fighting, less smell, improved appearances, and more equal feeding rates. We have also noticed an improved cleanliness of the monkeys' coats, cleaner windows, and some noise attenuation. During the study we were careful to use chips with no food in it. After the study was completed and when grain was given at twice- to thrice-weekly intervals, we have noticed that animals spend a considerable time foraging through the chips, in fact 30 times as much as when chips were first introduced and had no food in it, i.e., the behaviour analysis in this report. This probably contributes towards decreased fighting in the animals.

The experiment took place during a wet summer, and half the chips were often
wet from rain. The monkeys showed less preference for this area than for the dry area. We have concluded that in a stable, disease free colony, living under cover, woodchips are a preferable floor covering over a bare floor. Furthermore, it is an easily reversible flooring condition.

References

Deep Woodchip Litter: Hygiene, Feeding, and Behavioral Enhancement in Eight Primate Species
Arnold S. Chamove, James R. Anderson, Susan C. Morgan-Jones, and Susan P. Jones

Sixty-seven animals from eight primate species were used to assess improved husbandry techniques. The presence of woodchips as a direct-contact litter decreased inactivity and fighting, and increased time spent on the ground. Placing food in the deep litter led to further behavioral improvement. The use of frozen foods improved food distribution and reduced fighting in most situations, especially when it was buried in the litter. With time, the litter became increasingly inhibitory to bacteria. The results suggest that inexpensive ways of increasing environmental complexity are effective in improving housing for primates.

Introduction
A desirable objective in the management of captive animals is the creation of an environment adequate for the animals' physical and emotional needs. This is especially true for nonhuman primates in whom social, physiological, and intellectual pathologies result when important environmental considerations are neglected (McCrew, 1981). Environmental enrichment can be achieved by providing electrical and mechanical manipulanda (e.g., Chamove, in prep.; Markowitz and Woodworth, 1978; Murphy, 1976), or appropriate social stimulation (Chamove, 1973), or by attempting to approximate a more natural environment, for example by providing the animals with a deep-litter substrate on floors that were bare (Chamove and Anderson, 1979). The present article reports the results of the three studies concerned with two techniques of enhancing captive conditions for primates. Two studies examined the suitability of woodchips as a deep litter for various primate species. The third study also evaluated the effects of freezing fruit on its distribution and on aggressive behavior during feeding in a macaque group.

Study 1
A previous paper (Chamove and Anderson, 1979) suggested that litter was an effective floor covering for captive macaque groups. The rationale for its use was as follows: If an animal in its natural environment spends a substantial amount of time exhibiting a particular type of behavior, e.g., searching for food, while the animal in captivity is prevented from engaging in similar types of activity, the distortion in the animal's usual pattern of activity might be stress-
ful for the animal, leading to abnormal behaviors (Dawkins, 1980; Hediger, 1968; Meyer-Holzapfel, 1968). In captivity, food is usually presented once or twice per day, and it is therefore located and consumed in a short time. This contrasts with the extensive amount of time, up to 70 percent, that is spent in foraging activities in the wild (see references in Clutton-Brock, 1977; Harding and Teleki, 1981).

A second argument for the use of litter is an aesthetic one. Waste products are normally avoided by monkeys, but this is difficult when wastes are excreted onto solid floors. If monkeys avoid spending time on the floor of their cage because it is soiled, the area is being used inefficiently. Alternatively, the monkeys may be forced to spend time on a floor which they find aversive. Litter can serve to cover and absorb urine rapidly, and decompose feces. This study is an attempt to generalize the results of our previous pilot study of woodchip litter using stump-tail macaques (Chamove and Anderson, 1979) to a variety of other primate species.

Method

The seven species of monkey and one primate that were studied were moustached guenons (Cercopithecus cephus, N = 8), vervets (C. aethiops, N = 4), ring-tailed lemurs (Lemur catta, N = 3), stump-tail macaques (Macaca arctoides, N = 6), squirrel monkeys (Saimiri sciureus, N = 7), black-capped capuchins (Cebus apella, N = 7), red-bellied tamarins (Saguinus labiatus, N = 4), and common marmosets (Callithrix jacchus, N = 3). All were housed in Edinburgh Zoological Gardens, with the exception of the tamarins who were housed in a room in the Stirling University Psychology Primate Unit. The seven Edinburgh groups lived in indoor-outdoor enclosures. The outdoor areas contained dead trees and either grass or gravel on the ground. The floors of the indoor areas were of epoxy cement, and only this area was used for the study. Only the stumptails and tamarins had previous experience with woodchips on the floor.

Four conditions were studied: (1) baseline, i.e., bare floor; (2) woodchips on the floor; (3) woodchips plus grain; and (4) woodchips plus mealworms. Two days of observation were conducted under the first three conditions and 1 day under the fourth. Following the 2 days of baseline observation, new woodchips were spread on the floors to a depth of approximately 4 cm. One week later, observations were undertaken under this, the woodchip condition. On the following day, 500 g (approximately 800 cc) of mixed grain was scattered and raked into the woodchips, and 30 minutes later the group was tested (see below for the testing methodology). This procedure was repeated the following day, using one-third of this amount of grain. These 2 days constitute the woodchip + grain condition. The grain mixture contained primarily millet seeds, with a small amount of peanuts, sunflower seeds, dried currants, wheat, and kibbled corn. The following day, five mealworms per animal were scattered onto the litter, and 30 minutes later the group was observed in this woodchip + mealworm condition.

Each test involved one experimenter monitoring the group for 20 minutes between 2 and 4 p.m. A metronome sounded every 10 seconds, and any behavior occurring during each interval was noted once. Threats, rough grabbing, and biting were recorded as aggression; grimaces, cowering, and fleeing were scored as fear. Stereotyped movements, bizarre postures, and self-aggression constituted "abnormal" behaviors. Affiliative behavior involved grooming or huddling with another animal. Foraging was defined as manipulating the woodchips and intermittently transferring items found.
in the woodchips to the mouth. All scores were converted to a percentage of the intervals during which the subject was visible, i.e., indoors. The data were analyzed using analyses of covariance. The percentage of time each subject was observed on the ground on the first 2 control days, the bare condition, was used to obtain a measure of arboreality, which was then used as a covariate (see Table 1).

Three analyses of covariance were performed. All included species (N = 8) and condition (N = 4) as factors. In addition, percentage of time spent inactive or asleep was used as a repeated measure in one analysis, as were “negative” behaviors, i.e., aggression, fear, and abnormal activities, while “positive” behaviors, i.e., play and affiliation, were employed in the second analysis. The third analysis used percentage of time on the floor, percentage of time engaged in foraging, and time spent outside as repeated measures. Alpha was set at .05, and all reported differences are significant beyond this level unless specifically stated otherwise. The Least Significant Difference (LSD) method was used to further evaluate significant effects.

### Results

The results from all three analyses suggested that the addition of woodchip litter altered behavior. Surprisingly, the covariate had little effect: its largest beta estimate was only 0.20 for the analysis of foraging, indicating that the effect of the woodchip litter was not related to the degree of arboreality of the species. The forage analysis (Fig. 1) revealed two interesting effects (condition X behavior, and species X condition X behavior, both P < .001): (1) All species spent more time on the ground when it was covered with woodchips than when it was bare, and (2) when grain was incorporated into the litter, a further increase was noted. Since the foraging scores were very similar to the scores for the time spent on the ground, only the latter are plotted.

The social behavior analysis showed a significant condition X behavior effect (P < .005), and a significant species X condition X behavior interaction (P < .05). The positive and negative behavior scores are plotted in Fig. 1. Plots of the observed frequency of the two negative behaviors were parallel for the four sets of condi-

### TABLE 1. Time on the ground and agonistic behavior in eight species in different conditions

<table>
<thead>
<tr>
<th>Species</th>
<th>N</th>
<th>Time on ground in bare condition (%)</th>
<th>Time on ground in most effective condition (%)</th>
<th>Time exhibiting agonistic behavior (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guenon</td>
<td>8</td>
<td>39</td>
<td>68*</td>
<td>.20</td>
</tr>
<tr>
<td>Vervet</td>
<td>4</td>
<td>17</td>
<td>26*</td>
<td>.11</td>
</tr>
<tr>
<td>Lemur</td>
<td>3</td>
<td>9</td>
<td>87</td>
<td>.14</td>
</tr>
<tr>
<td>Stumptail</td>
<td>6</td>
<td>8</td>
<td>80</td>
<td>.63</td>
</tr>
<tr>
<td>Squirrel</td>
<td>7</td>
<td>5</td>
<td>13*</td>
<td>.20</td>
</tr>
<tr>
<td>Capuchin</td>
<td>7</td>
<td>1</td>
<td>28</td>
<td>.13</td>
</tr>
<tr>
<td>Tamarin</td>
<td>4</td>
<td>2</td>
<td>14</td>
<td>.52</td>
</tr>
<tr>
<td>Marmoset</td>
<td>3</td>
<td>0</td>
<td>11</td>
<td>.40</td>
</tr>
</tbody>
</table>

*In these 3 cases, the most effective condition was woodchip + mealworm; otherwise, it was woodchips + grain.
tions, but this was not true of the two positive behaviors.

With woodchips, the relative proportion of affiliative behavior making up the positive category decreased as the environment provided was made more interesting; play was 3 times more frequent than affiliation in the bare condition, 5 times more frequent in the woodchips-only condition, and 8 times more frequent in the woodchips + food conditions. With woodchips, the subjects showed less negative and more positive behavior, in comparison with the bare condition. Grain added to the litter reduced the level of positive behavior, probably because of its distracting effects. The activity analysis showed significant effects of species X condition, and condition X behavior (both P < .001).

Because sleep rarely occurred, only percentage of time spent inactive is plotted in Fig. 1. The provision of woodchips decreased inactivity.

These results suggest that the mere presence of litter leads to positive behavioral changes, even after the novelty effects of its presence have passed. All species were less inactive; all except squirrel and vervet monkeys showed more play; all except capuchins engaged in a lower frequency of abnormal and agonistic behaviors; and all except marmosets spent more time on the ground foraging. The addition of grain or mealworms to the woodchips greatly increased the time spent on the ground, reduced inactivity, reduced play and affiliative behaviors, and tended to reduce aggression even further than with litter alone. Grain was particularly attractive to the stumptail macaques, lemurs, and vervet monkeys, while mealworms were particularly attractive to the tamarins and moustached guenons. This effect is shown in Table 1, which gives the condition that produced the greatest amount of time on the ground for each species.

Study 2

Study 1 confirmed and extended the finding that the use of woodchip litter with captive monkeys leads to positive behavioral changes. Furthermore, in our previous report the chips were shown to be inexpensive; after 6 weeks, odor was less than with bare floors, and the animals and walls appeared cleaner when woodchips were provided than when there was no floor covering but daily cleaning was performed (Chamove and Anderson, 1979).

One criticism of using litter with monkeys focuses on the danger of a buildup of disease, with the implicit assumption (Department of Health, Education, and Welfare, 1972) that the longer the litter is left down, the greater the danger. However, evidence from research on poultry litter suggests precisely the opposite, by demonstrating that mature litter is inhibitory to many disease organisms as well as to yeasts and molds (Faneli, 1970; Snoyenbos, 1967; Tucker, 1967; reviewed in: Anon. 1978; Botts et al., 1952; Duff et al., 1973; Olesiuk et al., 1971).

Chicks reared on old litter have lower mortality and grow more rapidly than controls. In addition, their eggs show increased hatchability (Botts et al., 1952). The mere presence of old or new litter was shown by Duff et al. (1973) to eliminate the spread of salmonella among experimentally infected chicks. Although salmonellas survive for 3 to 4 weeks in feces (Berkowitz et al., 1974), in used litter they are substantially destroyed within 3 to 5 days (Olesiuk et al., 1971). The mechanism of salmonellacidal action is unclear, but there are suggestions that the increased moisture content (up to 20 percent), coupled with the high ammonia concentration and resulting alkalinity, are the critical factors (Turnbull and Snoyenbos, 1973). Study 2 assessed the potential for the spread of disease in litter used with macaque monkeys.
Method

Twenty-five stumptail macaques (Macaca arctoides), with a mean weight of 6.5 kg, were housed in an area composed of an indoor colony room and two outside areas of 33 sq m and 20 sq m respectively (described and illustrated in Chamove, 1981). All cages were interconnecting, and the animals were free to roam throughout the three areas. The outside pens were covered with mesh and partly covered with clear plastic. The floor area of each of the outside pens was covered with three 40-kg bales of woodchips. Twelve samples were taken from weeks 0 to 8 during July and August 1981. The samples were collected randomly from five different areas of a pen and mixed. Figure 2 illustrates members of a group of 25 stumptail macaques foraging through woodchips in an outside pen. Chips are covering only half of the pen floor.

Microbiological Analysis. One gram of the litter was taken, and serial dilutions were prepared using 1/4-strength Ringer solution (Oxoid no. BR 52) as the diluent. Appropriate dilutions were plated on nutrient agar (Oxoid no. CH 3) using standard techniques (Ministry of Agriculture, Fisheries and Food, 1968). Coli-aerogenes bacteria were counted at 30°C (Meynell and Meynell, 1970), using MacCartney broth (Oxoid no. CH 5a). All tubes showing acid and gas production after 48 hours were subcultured into duplicate tubes of fresh media; one tube was incubated at 37 ± 1°C, and the other at 44 ± 0.25°C.

Because salmonella is such a common and serious disease-producing organism in monkeys (Chamove et al., 1979), the inhibiting effect of the litter on Salmonella typhimurium was assessed by inoculating approximately \(10^3\) organisms into 1 g of litter in a MacCartney bottle.
and then shaking and incubating it at 22°C for 48 hours. The numbers of salmonella organisms in the litter after storage were estimated using the method described by Morgan-Jones (1982).

Results

Correlations of times (age of litter, expressed in weeks) with bacterial counts ranged from -.41 for the total count to -.60 for salmonella, and between -.70 and -.76 for the three coliforms. Although pH and percentage of dry matter correlated highly with week number ($r = +.65$ and -.59, respectively) and also with one another ($r = -.60$), the correlation between pH and week number did not seem to be caused by moisture content, since partialing out percentage dry matter did not substantially reduce the correlation ($r = +.50$).

Similarly, with one exception the correlation of bacterial inhibition with week number was not accounted for by either moisture content or pH of the litter. Partialing out the variance due to percentage of dry matter reduced the bacterial correlation with week number by only .04, on average; partialing out pH reduced it by only .03, except for the 37°C test (.14) and the total count, where it actually increased by .25.

It is clear from Fig. 3 that the total bacteria count decreased over the weeks. This was also true for coliforms isolated at 30°C, which include coli-aerogenes of both animal and nonanimal origin; 37°C, which reflect coliform bacteria of fecal origin; and 44°C, which reflect coliforms of very recent fecal origin. The survival tests for inoculated salmonella showed a similar pattern of reduced survival over the weeks. The numbers of salmonella...
rose from $2.9 \times 10^4$ per g in week 0 to a maximum of $2.4 \times 10^4$ in week 1, then gradually declined to a minimum of $4.3 \times 10^3$ by week 8 (weeks 2 to 7: $2.4 \times 10^4$, $3.3 \times 10^4$, $3.3 \times 10^4$, $4.6 \times 10^3$, $1.5 \times 10^4$, $1.1 \times 10^3$, $2.3 \times 10^2$). It is of interest here that the monkey litter was as inhibiting to salmonellas as is poultry litter (Morgan-Jones unpublished data).

These results show that the use of litter will not increase the risk of bacterial disease transmission and in fact appreciably reduces that risk. We have observed that after a period of about 12 weeks the monkeys spend less time on the litter and are less interested in searching through it. This behavioral criterion is useful in the scheduling of litter changes; we have decided that renewal every 4 to 6 weeks is optimal at our population densities.

Study 3

Fresh fruit and vegetables are usually given to captive monkeys to relieve the boredom of standardized diets. Two problems that often occur when feeding group-housed animals are: (1) the dominant animals are able to expropriate a disproportionate amount of the food, and (2) the food is eaten too quickly. We have observed that feeding solidly frozen fruits and vegetables to monkeys leads to better distribution and longer feeding times (Chamove, 1981), and have been using this method for the past 7 years with no ill effects. Study 3 was carried out to quantify and verify our earlier observations.

Methods

The Stirling colony group of 25 stumptail macaques was used. Their ages ranged from 6 months to 8 years, with a mode of about 2 years. Four experimental comparisons were made. (1) To assess the influence of incentive, three foods were offered in decreasing order of preference—banana, apple, and carrot. (2) To assess the effect of manner of distribution, food was either
massed in two piles or distributed evenly over the floor area. (3) To assess the effects of inter-animal visibility, the food was either distributed in the outside area where all subjects could see one another when feeding, or distributed over the same area inside where four opaque dividers with openings restricted visual contact among subjects. (4) To assess the effects of visibility of food, the food was either distributed on a bare area of the outside floor as above or buried under woodchips in the same area.

In all conditions two tests were run, one using fresh food, the other using frozen food. In all tests except experiment 1 the food used was apple. In each test the total weight of the food, cut into 45 pieces, was 1.25 kg.

Four measures were recorded on nine selected animals. The measures were (1) the number of food items eaten, i.e., picked up and more than one bite taken from it; (2) the number of items eaten plus sampled, i.e., dropped after only one bite was taken from it; (3) the number of agonistic interactions; and (4) the time that elapsed until all of the food had been consumed.

The analysis used analyses of variance with subjects divided into dominant ($N = 2$) and subordinate ($N = 7$) subgroups. All results reported below are significant beyond the .05 level unless specifically stated otherwise.

Results

Figure 3 illustrates the major significant differences observed. Under the condition in which food was distributed, freezing the food reduced aggression by a factor of 3 but had only a slight positive effect on distribution of food among the animals. In general, as the possibility of the dominant monkeys seeing and controlling all the food items decreased (under the conditions displayed from left to right in Fig. 4), the amount consumed by the dominants decreased, the amount eaten by the subordinates increased, and aggression was reduced. This effect was accentuated when the food was frozen.

The behavior of the dominant pair was more complicated. When the food was massed in two piles and frozen, the long feeding time led to aggression as the dominants attempted to control the two piles. When the food was distributed, fresh, and visible, aggression was also common due to attempts at control by the dominant subjects. Freezing the food reduced this aggression.

The test conducted inside, where dividing partitions restricted inter-animal visibility, was over in 2 minutes when fresh food was used, and aggression was infrequent. Aggression was slightly increased in the test using frozen food, which lasted much longer—24.3 minutes. Corresponding durations from the tests done outside were 6.4 and 19.0 minutes. To provide some perspective on these values, an adult stump tail eats an apple in about 1.8 minutes and a banana in about 0.9 minutes. A frozen apple or banana takes about six times as long to eat.

In the tests involving three types of distributed food, the dominants ate relatively more of the two preferred foods when it was offered fresh than when it was frozen, but not of the carrot. Aggression by the dominant monkeys was over four times greater for banana and apple when these were fresh than when they were frozen, but aggression was roughly equal (when fresh) and much lower (frozen) for the carrot.

Discussion

The results of the present studies clearly show that there are advantages to using woodchips as a substrate for monkeys. These data thus support the conclusions reached in a previous study
with stumptail macaques (Chamove and Anderson, 1979). In the present study, using more species, aggressive behavior was reduced by a factor of 3 with woodchips and by almost 10 times with grain or mealworms added to the litter. All negative behavior decreased by a factor of over 5 when food was added to the woodchips. Time spent on the ground almost doubled with woodchips, and more than doubled when food items were added to it. These effects occur in monkeys of various ages. Figure 5 illustrates a group of stumptail monkeys foraging through woodwool, another type of litter we are evaluating. We have observed that it does not “pack” in the same way as woodchips do, and may therefore be left down longer.

In addition to searching through the two types of litter, juveniles also engage in playful gymnastics in them, more so than on a bare floor, and more on woodwool than on woodchips.

In addition, there is no evidence that using woodchips presents a health hazard. As the litter matures, the woodchips become increasingly more inhibitory to bacterial survival. This self-sterilizing action makes it likely that the mere presence of an absorbent litter greatly reduces the probability of disease spread due to fecal contamination.

The freezing of food also has advantages in certain situations, leading to improved distribution and less fighting. This is particularly true when the dominant animals cannot “control” the food sites. Distribution of the food per se in a small enclosure may not reduce aggression, because the dominant animals may try to monopolize most of the food that they can see. One method of reducing the dominant animals' ability to control the food—burying it—resulted in improved distribution and prolonged feeding times. We regularly bury small food and non-food items in the woodchips, which the monkeys seem to enjoy discovering.

In conclusion, we recommend deep litter as one technique of enhancing conditions for captive primates. It has real potential for promoting good health and induces positive kinds of behavior among species that invest a great deal of time and energy in foraging in their natural environment.

Acknowledgments

The authors wish to thank M. Stevenson for help and permission at Edinburgh Zoo, and Miss A. Coles for technical assistance with the microbiological analysis.

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FIGURE 5. Macaques foraging on wood-wool litter.

Introduced Species and the Issue of Animal Welfare

Michael Hutchins, Victoria Stevens and Natasha Atkins

Recently, considerable debate has been heard about the control or elimination of introduced or “exotic” animals on publicly held U.S. lands. Species introductions, whether intentional or unintentional, seem to be an inevitable result of human activities, but they may result in both economic and ecological problems: It has been estimated that over 90 percent of all such introductions have been harmful in some respect. Control of exotics can be accomplished through containment, shooting, poisoning, reintroduction of native predators, introduction of disease organisms, live capture and removal, and reproductive inhibition.

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ALLOWING CAPTIVE PRIMATES TO FORAGE

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Introduction

Recently there has been an increase in research devoted to improving the behavioural aspects of housing captive animals (Markowitz, 1982). It is evident that if an animal is adapted to spending much of its waking time searching for and processing food, this waking time must be taken up in other ways when the animal is captive and when food is provided independent of its behaviour. Other behaviours might increase, be modified, or created to fill the free time. Abnormal, aggressive, and/or affiliative behaviours tend to increase in captivity, depending on the species and the degree of change caused by the housing conditions.

Aims

It has been shown that providing monkeys with a floor-covering such as woodchips, containing an incentive such as grain, has several advantages, including reduced aggression and inactivity, more even use of space, and improved hygiene (Chamove & Anderson, 1979; Chamove et al, 1982). In an effort to further understand the beneficial effects of using a deep-contact litter containing grain, in the experiment reported here we asked 6 questions:

1. Will monkeys forage through woodchips if there is no grain?
2. Will they search through the woodchips even if grain is available without the need for searching?
3. Will behaviour change during periods when the opportunity to forage has been removed?
4. Will behaviour change when the opportunity to forage has been reinstated?
5. How do two different floor coverings compare?
6. Does grain in the litter again lead to behavioural improvement?

Method

Eight young stump-tailed macaques (*Macaca arctoides*) were tested, part of a group of ten that had been housed in an indoor/outdoor enclosure (floor area 36 m²) for several months. Five conditions were used, each lasting two consecutive days. Existing litter was cleared and 38 kg of clean woodchips were spread on half of the floor of the outside area to a depth of 4 cm. An equal weight of woodwool was spread over the other half. After two days testing began:
a. the eight monkeys were observed for two days with no grain in the litter
b. the litter was removed for two days and the floor left bare
c. the litter was then returned, but again without grain for two days
d. following this, 700 g (1000 cc) of mixed grain were distributed equally between the two types of litter, half on each of two mornings
e. finally, the same amount of grain was given, but an ad libitum amount of free grain was also available to the monkeys in food hoppers indoors, making foraging through the litter for grain unnecessary.

We recorded all instances of the following behaviours which occurred during an average of 110 1-minute scans conducted daily: aggression, abnormal, foraging, manipulate litter, manipulate environment. We also recorded the location of the monkeys performing the behaviours, i.e. on woodchips, on woodwool, or off the substrate. An analysis of variance using the percentage of scans recorded was used to assess the data for each behaviour.

Results

The main results are shown in Figure 1. In the first clean litter condition the monkeys were recorded foraging 3 per cent of the time. After two days of deprivation, foraging on the returned litter approximately doubled. Adding grain to the litter caused a huge increase in foraging, to over 30 per cent of the time, this dropping by about half when free grain was offered, but foraging was still much more common than with no grain in the litter. These results indicate that finding grain in the litter is rewarding for the monkeys, even if grain is freely available without the need to search for it. Furthermore, monkeys will search through grain-free litter for no food reward, and this behaviour shows an increase after they have been deprived of the opportunity for such foraging. This suggests the presence of a ‘drive’ which finds an outlet in the deep litter.

Compared to the grain condition, the free grain days produced few other effects. In contrast, the monkeys were more aggressive, and manipulated the litter more (mainly playfully) during the first litter condition than in the grain condition. The second litter condition, i.e. after two days of deprivation, showed an increase in play on the litter compared to the first. In the bare condition the monkeys showed most play, aggression and ‘abnormal’ behaviour (mostly self-aggression).

The monkeys showed a general preference for the woodwool, manipulating it twice as much, and playing in it thrice as much as the woodchips (see Figs 2 and 3).

A final summary comparison between the bare floor and litter with grain showed that in the latter monkeys foraged more, manipulated the environment less, were less aggressive (towards others and themselves), and played less. The decrease in play is more than offset by the increase in foraging and the decrease in aggression.
Figure 1 Six behaviours over the 5 conditions

![Bar chart showing percentage of scans for behaviors across conditions](chart.png)

**Figure 2** Monkeys foraging through woodchips

![Monkeys foraging through woodchips](image.png)
Conclusions

This study shows that when deprived of the opportunity to forage, monkeys compensate by increasing other behaviours; our young group showed increases in play, aggression, manipulation of the environment, and abnormal behaviours, primarily self-aggression. A litter substrate reduces these behaviours and encourages foraging, even in the absence of grain. In another study we have also shown that the beneficial effects of deep litter:

a. generalize to other primate species, and
b. that the litter is inhibitory to the growth of several types of bacteria (Chamove et al 1982).

REFERENCES

Moving Callitrichid Monkeys From Cages to Outside Areas

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To assess the important aspects of a large area for environmental enrichment, the behavior of families of common marmosets Callithrix jacchus and cotton-top tamarins Saguinus oedipus when in laboratory cages and when in much larger outside areas was compared. All animals avoided areas with little cover. The two tamarin families preferred an indoor cage to a large open area with little cover and consequently only showed a limited range of behavior when outside. When dense cover was provided to the marmoset family, they used this area extensively, showing a wider range of behavior than when in cages and shifting to less active behavior patterns. By feeding marmosets in a central area, it was possible to allow unlimited access to the outside while effectively containing them.

Key words: marmosets, tamarins, environment, enrichment

INTRODUCTION

There has been considerable recent interest in improving captive environments, and much of the research has centered on zoo environments [e.g., Chamove et al., 1982; Erwin and Deni, 1979; Glatston et al., 1984]. Most of these studies have involved the addition of devices [Dathe, 1981; Markowitz, 1982; McKenzie et al., 1986] or material [Chamove and Anderson, 1988] that increase the complexity of the simple enclosure. One limiting factor has been the size of the enclosure. Traditional laboratory cages have been quite small, the legal requirement being just large enough to allow the animal to lie down and to stand up [Fox, 1986]. Callitrichid cage sizes range from .2 m$^3$ to 27 m$^3$ in laboratories [McGrew et al., 1986; Snowden et al., 1984] to 1.6 m$^3$ to 3.6 m$^3$ in zoos [Glatston et al., 1984]. It is known that breeding success varies in these monkeys, improving with larger cage sizes [Snowdon et al., 1984]. Behavior would also be expected to change with cage size [Archer, 1979; Chamove et al., 1984]. But in larger cages, factors other than simple size might
be expected to become important in influencing behavior, such as branch spacing, cover, orientation, etc.

One way of increasing cage size and variability is to allow animals access to outdoor enclosures [e.g., Fragaszy, 1979]. When sifakas were housed outdoors, they were more active, foraged more, and were less inactive [Macedonia, 1987]. It would be ideal to eliminate the need for enclosing fences. Two published studies have reported allowing callitrichids to roam free. One describes the behavior of a single elderly male common marmoset [Wendt, 1962], the other describes a family of six cotton-top tamarins [Heusser, 1967]. Both authors report that their monkeys returned to a nest and feeding area located in a house. Both say the animals would go out in the winter if they had access to a warm area, but would only go out for short periods (30 min) if the temperature was below 15°C when raining or if below 5°C when dry. The marmoset ranged mostly within 200 m of the house but occasionally to 400 m. He would carefully cross flat areas as wide as 15 m, and it was very wary when catching grasshoppers in the grass.

Apénehuel Zoo allows four species of Callitrichidae to roam semifree within a large fenced enclosure. They report that it is only when the parents were born in a semifree-ranging situation that they subsequently roamed the entire territory [Mager and Griede, 1986]. Then they used over 1.5 ha of woodland. This suggests that cage-raised animals may take considerable time to use the environment in a natural way.

This paper reports behavioral changes when three groups of two species of callitrichid were moved from laboratory cages to a much larger outside area. One species could move freely between the two areas, whereas the other did not have the choice. Will such enrichment lead to a change in behavior, and will the change be a “beneficial” one? Can the placement of food and a nest box be used to restrict the ranging of these monkeys?

**PART ONE
METHODS**

Two of four laboratory-born common marmosets (Callithrix j. jacchus) living in a family group were the parents (1.5 years of age), and two were their twin sons (3 months of age) at the start of observations. The four lived together in a wire mesh cage 3 × 2.1 × 1.4 m, and the parents had been so housed for 5 months prior to infant testing at 5 weeks of age. Feeding and housing procedures were as described in McKenzie et al. [1986]. Although making up a large proportion of the natural diet in the wild [Lacher et al., 1981], plant gums were not offered to the animals.

After 7 months of laboratory housing the family was moved to a 3.1 × 5 × 2.5-m brick enclosure in May with a 1.5 × 1-m window to the outside. This enclosure had a nest box and poles; the floor was covered with woodchips. After living in this area for 2 weeks, a small 10 × 10-cm hatch was opened above the window giving the animals free access to the outside. For the first 2 days a 1 × .5 × .5-m cage allowed the animals only limited access to the outside area. Then the cage was replaced by a heavy board 10 cm wide giving access to bushes 3.7 m distant at a height of about 2 m. Thereafter the hatch was never closed.

All feeding occurred in the brick enclosure, and food was offered twice a day. A variety of high-protein chow, yoghurt, nuts, cottage cheese, meat, fish, eggs, etc.
were available at daylight, and fruit and vegetables were given between 0900 and 1000 hr.

The outside area included what was once a walled garden—long neglected—containing trees, shrubs, and vines. The 4-m-high wall passed near the exit hatch and extended for about 40 m where it turned at right angles for a further 48 m. There was continuous woodland for several kilometers, and the animals could move throughout a wide area without needing to come to the ground. The plants growing adjacent to the wall are listed in Table 1 ranked in descending order of frequency; potentially toxic plants [Clark, 1982] are indicated by an asterisk. The largest trees near the wall were ash, maple, and whitebeam with a circumference of 240, 150, and 145 cm, respectively, at 2 m.

Ivy covered most of the wall and extended out from the wall over 1.4 m in a tangle of old and new stems. Toads (Bufo vulgaris) and semiwild domestic cats were also seen, but were not approached by the monkeys, whereas Kleiman et al. report great interest in toads in their tamarins [1986]. Presumably other indigenous Scottish wildlife were present although not seen.

Observation of the four marmosets occurred during three periods: 1) in the small cage 1 month prior to release, 2) outside 3 months after their release, and 3) 2 months after being returned to the small cage. Each of the three observation sessions consisted of a minimum of 8 days of observation, each observation lasting 30 min for each of the four animals. During observation, data were collected for one animal at a time, and the following behaviors were recorded: jump, climb, hang, run, play with another, walk, search, sit, huddle with another [defined in McKenzie et al., 1986]. Behaviors were mutually exclusive. Animals were observed unsystematically during the whole day, but an attempt was made to sample at least once from every daylight hour while animals were outside the nest box.

Because of the variability of the durations of different behaviors, all were observed using 10-sec intervals, and the frequency of a behavior was noted once during that interval if it occurred, i.e., one-zero sampling. This meant that searching through leaves would be recorded only once in a 10-sec period even if it appeared to occur more frequently. Although not true frequencies, these frequencies correlate highly with true frequencies [Chamove, 1974]. Also noted was the frequency of descending to the ground. Because of the rapid development of the juvenile monkeys during the study, the data from the two tests in the cages were combined for all the animals for the analysis. The comparison was therefore between behavior in cages with that when outside. Analysis of variance was used to compare conditions. All results reported were significant beyond the .05 level unless specifically stated otherwise. Because data sessions varied in length, data were converted into frequency per 10-min periods for analysis and presentation here.

Infant locomotion was recorded in a similar manner whenever infants reached 5 weeks of age, although here only 4 days of data were taken. Also recorded was the duration of parental grooming of infants at that age. The comparison was between two male infants born in the small cage with two males born after release. These two categories were the only infant data collected.

RESULTS

The general results showed that the overall amount of activity was similar under the two conditions, although the animals spent rather less time engaging in inactive
TABLE 1. Trees, shrubs, vines, and herbaceous plants to which the marmoset family had easy access

<table>
<thead>
<tr>
<th><strong>Trees</strong></th>
<th><strong>Vines</strong></th>
<th><strong>Shrubs</strong></th>
<th><strong>Herbaceous</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild cherry, <em>Prunus avium</em></td>
<td>Cherry laurel, <em>Prunus laurocerasus</em></td>
<td>Hazel, <em>Corylus avellana</em></td>
<td>Bracken, <em>Pteridium aquilinum</em></td>
</tr>
<tr>
<td>Beach pine, <em>Pinus contorta</em></td>
<td></td>
<td></td>
<td>Ragwort, <em>Senecio jacobea</em></td>
</tr>
<tr>
<td>Common larch, <em>Larix decidua</em></td>
<td></td>
<td></td>
<td><em>Potentially toxic plants.</em></td>
</tr>
<tr>
<td>Oak, <em>Quercus robur</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Potentially toxic plants.*
behavior when outside. However, the pattern of activity was not similar, animals showing less vigorous activity and more of slower activities when outside. The most striking change in the behavior of the animals was the branch type they chose to use. In the cages they spent most time on flat mesh surfaces and horizontal branches with infrequent (.8/min) visits to the floor. Unrestricted outside they spent most of the time (89%) in the dense network of thin flexible ivy vines, behavior similar to that described for the Geoffroy's tamarin (Saguinus oedipus Geoffroyi) [Garber, 1984, p. 116]. They rarely visited more open shrubs (10%) or trees (1%) where they could be easily seen at a distance. As also reported for titi monkeys, but not for squirrel monkeys [Fragaszy, 1979], the monkeys were never observed on the ground or on the flat grass-covered roof of the brick enclosure. A photometric measure of luminance from a sample of these three habitats (dense vines, open shrubs, grass) taken on a sunny day have values of 50,000, 320,000, and 700,000 lux, respectively, using a UDT 40X opto-meter. Measures taken from the laboratory cages on a sunny day were comparable to the values recorded in the trees.

As the animals were captive born and habituated to observers, they could be approached to within 2 m even when outside and so could be observed in dense vegetation. Because the family was usually in dense vegetation, they could rarely be observed at a distance, but the movement of vegetation easily revealed their location. They were always observed travelling together.

The daily range of the monkeys was the full length of one side of the ivy-covered wall (40 m) extending a few meters around the corner. The greatest distance traveled was an additional 46 m around the corner. They also ranged outward up to 15 m from the wall into more open bushes and into medium and large trees, most commonly to gouge for tree gum.

The monkeys returned to the brick enclosure to feed at least once a day, and usually once in the early morning and again in the evening. After about 2 months the family began spending the night sleeping in a dense tangle of old ivy stems at the top of the wall. They entered from above, descending about .4 m to the wall; this site was not protected from rain.

The monkeys were regularly observed feeding from gouges they had made in elm trees (illustrated in Fig. 1). Single gouges were also seen in a few birch, lilac, and thick ivy branches, all about 21 cm in circumference where gouged. Gouge patterns were recorded from all of the elm used by the animals and the results are presented in Figure 2. Three analyses of variance were carried out to see whether the pattern of gouges differed between the five elm chosen by the monkeys or whether the pattern was the same on each. The results showed that the trees differed in girth at the gouge sites (F (4/19) = 31.4, P < .01) and height at which the gouges were made (F = 8.3, P < .01).

The results of an analysis combining the length, breadth, and depth of the gouges showed a significant interaction suggesting that although the depth of gouge did not differ between trees, the length and breadth did (F (2/38) = 13.9, P < .01). The gouge length ranged from an average within trees of 1.3 to 7.1 cm, and the breadth ranged from .7 to 3.3 cm. Intercorrelations between the five measures and the number of gouges per tree showed strong associations of length with breadth of gouges (r = +.83, P < .01) and between the number of holes per tree with 1) gouge length (r = -.63, P < .01), with 2) gouge breadth (r = -.40, P = .05), and with
Fig. 1. Two adult and one juvenile marmoset gouge on elm trees.
Fig. 2. The height from the ground (left) and the circumference (right) of all gouges made in five elm trees by marmosets. Gouges (circles) within trees are connected by vertical lines for clarity.

3) girth at the gouge ($r = -0.48$, $P < .01$). There were a greater number of gouges in areas of smaller tree girths and when the gouges were shorter.

As shown in Figure 3, there were significant reductions in the more active behaviors jump and play when the animals were outside and a significant increase in less active behaviors climb and hang, walk, and search. The animals spent significantly less time huddling together.

The comparison of the two sets of twins at 5 weeks of age showed that there was no significant difference in the overall level of activity depending on whether they had been born in and were living in laboratory cages or when born in and living in a seminatural setting. Both showed activity levels close to 25 bouts/hr. Also no significant differences were found in the amount of parental grooming of the infants (.2% of observation time).

Animals responded to soaring birds of all kinds by leaping into dense bushes and remaining still. When a dead weasel (Mustela nivalis) was wedged into some branches in a life-like position, three of the four mobbed the animal, the father carrying the babies approaching the least; the adult female approached to within 10 cm. The marmosets appeared to ignore a large rubber snake located on the ground or in the branches, even when the head was made to move [see Heymann, 1987]. In the laboratory, the monkeys reacted to soaring birds as well as to airplanes, giving calls and then approaching the skylights.

The only invertebrates that could be identified as being eaten by the animals were snails [also Heusser, 1967; Wendt, 1962].

**PART TWO**

**METHODS**

**Subjects.** Two families of cotton-top tamarins (Saguinus o. oedipus) were observed at the German Primate Center. Each of these families consisted of a
Eight behaviors (mean frequency per animal) shown by a family of marmosets in laboratory cages (hatched) and when in the open (open).

Housing. Both families were housed in indoor rooms of about $3 \times 3.5 \times 2.5$ m. The rooms had wire mesh on the front and concrete walls; they were equipped with a system of branches (horizontal, vertical, and diagonal), boards, and a sleeping box. Next to these groups lived two other families that could hear and smell, but neither touch nor see one another. Artificial lighting in the indoor room was turned on by a time switch at 0600 hr and off at 1800 hr. These rooms also had skylights where natural light came in. Air temperature was approximately 26° C, and humidity was maintained at approximately 65%.

In summer 1983 for group I and summer of 1984 for group II an outdoor mesh cage measuring $1 \times 2 \times 2$ m was connected with the indoor room through a channel of $40 \times 60$ cm, which could be closed by a guillotine door. This outdoor cage also contained branches, one leading from the exit of the indoor room to the outside. The cage was built within an outside area of $45 \times 27$ m to which the animals had access after they had been familiarized with the outdoor cage. The large area was enclosed by wire mesh on the lower part of the walls, and on the upper was an incline made of concrete; it was open to the sky. A "road system" of horizontal branches was constructed approximately 1 m above the ground. Small bushes of live willow were
planted; grass and maize grew in the area. In contrast to the wild garden described in Part I, there were no trees. It was more like bush vegetation, with bushes and branches throughout the enclosure. The distances between “thick” bushes were about 1–2m.

The monkeys were fed twice daily: At 0730 hr they were given a pulp with vitamin supplements and pelleted food; at midday they were offered a different pulp plus bananas, apples, rusk or crispbread, mealworms, and a variety of fresh fruit and vegetables. Twice a week they were fed live locusts. Details of the diet are described elsewhere [Kaumanns et al., 1986]. When the tamarins had access to the outside cage they were also fed fruit and vegetables there, but they were never fed in the large area.

**Procedure.** During three of the summer months the two families had access to the small outdoor cage. First the animals were allowed to use the outdoor cage at fixed times (1030–1230 hr; 1500–1600 hr) and only in the presence of the observer, but subsequently they could enter and leave as they liked. After about four weeks when they were accustomed to the outdoor cage they were allowed to use the large area. Then, the animals could use the outdoor area everyday, except when it rained, and only in the presence of the observer.

One or two sessions of observation took place each day. A total observation time of 24.5 hr for group I and 17 hr for group II was accumulated, that is, 16 periods for each group when outside. It was noted which member/s of the group used the outdoor cage/area and their behavior in a 1-min (group I) or 0.5-min (group II) interval. The behavior categories followed the definitions given by Wolters [1978b] and were as follows: locomotion, resting, resting in contact, autogrooming, allogrooming, anogenital marking, suprapubic marking, playing, eating, agonistic behavior.

The observer sat behind a window where she could see the monkeys only when outside, and where the animals could be heard only slightly.

In addition, observations in the indoor cages took place [Rohrhuber, in prep.]. For comparison with data outside, data will be used that were collected in the summers of 1983 (group I) and 1984 (group II). For analysis, data for “outside” was made up from data when the animals were in the outdoor cage and in the large area as there was too little to be considered separately. All statistical comparisons were two-tailed chi-squared tests.

**RESULTS**

The first individuals to venture out were the fathers in both families, followed by their offspring. All members of the groups went outside, but they differentially used the outdoor cage/area (see Fig. 4) (group I: $X^2 = 443.5, \text{df} = 5, P < .01$; group II: $X^2 = 1,152.2, \text{df} = 4, P < .01$). Even the mother of group I came out when she had a 2-day-old infant on her back.

Although the monkeys were outside more commonly alone than in any other single grouping, in most cases individuals were outside with others, although not as a complete family group (see Fig. 5) (group I: $X^2 = 407.3, \text{df} = 5, P < .01$; group II: $X^2 = 782.1, \text{df} = 4, P < .01$), either indicating that group cohesion was weak or more likely that the environment was more aversive than for the marmosets [McKenzie et al., 1986].

Comparing the behavior shown outside and inside, the monkeys showed fewer
categories of behavior outside, e.g. outside they showed little grooming or resting while in contact. The tamarins showed primarily locomotion behavior outside. Group II did not show any resting behavior outside whereas they did inside. In group I, too, resting behavior was shown significantly more inside than outside ($X^2 = 3.2$, df = 1, $P < .05$). Eating and playing could not be compared because there were too few data
for group I, but group II ate and played more inside than outside (eating: $X^2 = 1.8$, df = 1, $P < .01$; playing: $X^2 = 4.3$, df = 1, $P < .025$).

All tamarins took food offered to them outside at the regular feeding time. They also caught and ate flies but were never seen to eat grass seeds on the ground. They also very seldom jumped onto the ground; instead they most often used the branches or the wire at the side of the cage. The tamarins only used the part of the area near the outdoor cage that was under cover of the concrete wall. The furthest point one of the subadults went away from the “home cage” was approximately 20 m away, but usually they stayed within 3 m of the outdoor cage.

The monkeys spent time outside in sunny or cloudy weather when the temperature was between 12°C and 25°C. They were responsive to potential aerial predators such as the common kite (Milvus milvus), black kite (Milvus migrans), kestrel (Falco tinunculus), or buzzard (Buteo buteo), which sometimes flew above them. One animal would give a call, and then all would immediately run inside. Smaller birds such as robins (Erithacus rubecula) or domestic cats walking around the fence of the large area were observed by the monkeys and did not appear to upset them.

Both families behaved similarly in the large outside area: Although they appeared to be curious concerning the outside, it took a long time before they were confident enough to show “intimate” behavior such as grooming, and they never showed very much or as much as when inside. In both families, the offspring were more often outside than the parents.

DISCUSSION

The common results of the two studies were that all the monkeys avoided the ground and uncovered areas: In the wild garden, the marmosets preferred to travel in the trees and especially in the dense ivy; at the German Primate Center, the tamarins stayed only under the inclined wall. In agreement with previous findings [Heusser, 1967; Wendt, 1962], the monkeys quickly became accustomed to the climate, and they went out even when it was not as warm as inside.

Both species were responsive to potential aerial predators but were less responsive to cats or snakes. This supports the presumptions by Beck et al. [1986] that some of these reactions are genetically based in that both groups were laboratory born and had no prior experience with predators. The lack of interest in snakes and the close approach to a dead weasel suggest that these laboratory-reared monkeys may not be showing adaptive responses to this class of stimuli [Kleiman et al., 1986]. The successful avoidance of toxic foods and amphibians is attributed to the fact that the marmosets were well fed and not under pressure to exploit less desirable foods.

In the tamarins, younger animals were those who seem to “profit” most from the larger space available. They used it most often and more quickly developed motor skills. This confirms results found when reintroducing callitrichids into the wild [Beck et al., 1986; Kleiman et al., 1986].

As was found by Fragaszy [1979] for titi and squirrel monkeys when they were allowed daily access to a 1-ha enclosed outside area, both species selected certain areas, which they used much more than other areas. In callitrichids the close availability of dense cover seems to be a critical factor enabling them to make use of large areas. The provision of grassland, shelter, a nest box, and especially food all served to limit their ranging and acted as an effective barrier for the family group.
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ENRICHMENT IN CHIMPANZEES:

UNPREDICTABLE ROPES & TOOLS

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Chimpanzees at the International Research Center of Franceville in Gabon live in two situations, either in 6 x 10m barred enclosures (voliere) in groups of from two to five or in a much large enclosure with five animals. Most animals were wild-born but were confiscated in infancy. As both types of enclosure have little for the animals to do, three types of environmental enrichment were assessed. The evaluation measures were the time the animals spent with the enrichment device, the longer the time, the better the device; and the behaviours exhibited by the animals.

Ropes

I have observed that apes in zoos rarely use the ropes hanging in their cages. In an attempt to vary the complexity and unpredictability of ropes, we put five new ropes into a voliere containing five adult chimpanzees.

1 - The standard 3m rope hanging from the cage roof.
2 - A 3m hanging rope with a tyre on the end similar to what they normally had.
3 - A 3m length of rope lying on the ground.
4 - A 6m rope hung over the roof bars in an inverted U and able to be pulled through the bars.
5 - A rope as in 3 above but extending 3m into an adjoining voliere with two chimpanzees. These two animals could not be seen by the larger group. The end of this rope would at times appear to leap spontaneously up to the roof. Knots at the ends of the ropes prevented them being pulled through the bars.
When first released back into the voliere, animals were most interested in the loose rope. This may be because it was the only loose item in the cage. On subsequent days it continued to be used but usually with other ropes. Over 10 days of observation, there were two different preferences. Primarily the animals spent most time on rope 4, where, by holding both ends, they could vary what could be done with the two. The second preference was for rope 5, but only when it was being manipulated by the chimpanzees in the adjoining cage. When the rope appeared to be spontaneously moving, it was almost always played with by some animal. It seems that making a rope more complex made it more attractive.

Tools

If enrichment devices are to be used in zoos, they have to be inexpensive to make, easy to maintain, but occupy animals for a long period (Chamove, 1981; Millar et al., 1988). With chimpanzees the task is made easier as they will make and use tools for time-consuming extraction of small items of food. Artificial termite mounds have been constructed, but they are difficult to bait and so usually left unused (Nash, 1982; also personal observation).

A wooden board 1.2 x 0.4m was placed flat outside the bars of a voliere (see Fig. 1). Three rows of three nails were put in the board to increase difficulty. Peanuts could be easily scattered at the far end of the board. A border of 1.5cm wood kept the nuts on the board. Animals were given long (2m) stems of aframomum, a bamboo-like grass. They could then strip the leaves and use the stem to guide the peanut kernels to the edge of the board and then under the bars of the cage.

Figure 1. Chimpanzee guiding peanut kernel towards the bars of its cage with a long aframomum stem (from photo).
The device was tested on three voliere. Depending on how far the kernels were from the cage, the animals took between nine and 110 seconds to retrieve a peanut once they began. Some individuals would use the stem still with leaves to draw the nuts closer to the bars; when the nails interfered they would change to a stripped and bare stem to guide the nuts through the maze of nails. Observing over three-hour periods, individuals were seen to spend as much as 70 minutes using the device.

A tennis ball which had been modified was the second device to be tested. A small hole was cut in the ball such that peanut kernels could be easily placed inside. The ball was supported in a mesh basket outside the bars of the voliere. The task for the chimpanzee was to use an aframomum stem to turn the ball so that the hole was located at the bottom and a kernel would fall out; then the animal could retrieve the kernel from the ground using the stem. It was necessary to start with a large-holed ball to teach the task.

The task was a difficult one and the most adept individual, the infamous "Mangostan", could extract one kernel after working for about five minutes. He would spend over two hours working on this device in a day. Two other chimpanzees took much longer - about 15 minutes - and would often stop working on the device; they would spend just under an hour manipulating the tennis ball.

Summary

The unpredictable rope was an improvement on the usual rope equipment and, because of its low cost, was probably a cost-effective enrichment device. Both devices requiring the use of tools were effective for environmental enrichment, being inexpensive to build, maintain, and to bait; and both were sufficiently difficult to require considerable time to obtain the reward.

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Are alarming events good for captive monkeys?

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ABSTRACT


To evaluate a hypothesis suggesting that brief arousal may be beneficial to laboratory animals, 39 cotton-top tamarins living in four families were observed following stimulating husbandry procedures. Arousal led to an improvement in behaviour (i.e. decrease in activity and an increase in affiliation) during the remainder of the day, changes similar to patterns reported as positive effects of enrichment but opposite to negative effects of long-term stressors; a wider range of normal behaviour; but we found no evidence for an improved response to challenge.

INTRODUCTION

Elsewhere we have argued that the goal of enrichment should be to provide conditions enabling animals to approximate the full range of normal behaviour in captivity, and that the mechanism for this is to "increase psychological space" by providing natural stimuli, albeit in a modified form (Chamove and Anderson, 1989). We have suggested four criteria for "more normal" behaviour: (1) a reduction of abnormal behaviour; (2) an increase in the range or number of normal (i.e. wild) behaviour patterns; (3) behaviour patterns which are more normal in their temporal distribution during the day; (4) an ability to cope with challenges in a more normal way.

While most animal welfare researchers advocate the reduction of stress, a few suggest that low-intensity arousal may be "adaptive", and presumably, as a consequence, healthy (Dantzer and Mormede, 1983; Ewbank, 1985). We feel that it is the duration of the arousal rather than its intensity that differentiates healthy from unhealthy arousal. Research results offer at least four sources of indirect support for the idea that arousal is beneficial, as long as it

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is brief. By brief we mean that the animal’s adrenal response does not extend into the period of exhaustion (Selye, 1974).

(1) Animals apparently seek out challenge when living in captivity (Harlow, 1950; Havelka, 1956; Anderson and Chamove, 1984).

(2) In the wild, where animals have more control over certain stimulus variables and over more response variables than they do in captivity, an avoidance response can stop a stimulus thereby making it "brief". Reduction of control by being in cages is exemplified by the effects of visitors (a prolonged stressor) on the behaviour of zoo animals (Glatston et al., 1984; Chamove et al., 1988). Visitors are associated with increases in activity and abnormal behaviour, and with decreases in inactivity, grooming, and affiliation.

(3) Several lines of research have shown that increasing the range of foods eaten (Kirkwood and Dow, 1986), the range of muscles used (Turnquist, 1986), and the range of stimuli to which one is exposed, is healthier (Fox, 1986; Paterson and Pearce, 1989).

(4) Research suggests that low levels of arousal produce individuals that over-react both in intensity and duration to mild stimuli and to prolonged arousal (e.g. Stolba and Wood-Gush, 1980; Garmezy, 1982). Brief arousal experience early in life enables individuals to cope better with stressors when they are older (Denenberg, 1964; Ewbank, 1985; but see Daly, 1973).

All these studies show long-term beneficial effects of stressors occurring early in life; we could find only one study of short-term effects (Chamove, 1986). The logical extension of this position is that the presence of natural levels of excitement or stimulation is desirable, either to prepare the individual for future challenges or to produce normal stimuli and thereby more normal behaviour.

In this study we observed the behaviour of four large tamarin families on days during which three types of intense but brief arousing experiences occurred, and compared it with behaviour on days with typical uneventful laboratory experience. The arousal was in the form of normal laboratory experience, but presented in a controlled manner and consisted of capture and removal of monkeys from their group and birds passing overhead. We then assessed whether this brief excitement was beneficial for laboratory-housed monkeys by comparing resulting changes with both the aversive behaviour change produced by long-term stressors, and with the beneficial change produced by environmental enrichment. This was achieved by seeing if a wider range of more normal behaviour was produced, and by seeing if monkeys could cope more effectively with challenge. Five studies of enrichment (Chamove et al., 1982; Anderson and Chamove, 1984; Westergaard and Fragaszy, 1985; McKenzie et al., 1986; Boccia, 1989) and three of stress (Glatston et al., 1984; Worsley-White, 1988; Chamove et al., 1988) suggest that six behaviour patterns decidedly differentiate between enrichment and stress effects in monkeys: groom, touch, agonistic, abnormal, low and high locomotion. As
our monkeys rarely show agonistic and never show abnormal behaviour, this study concentrates on the four remaining behaviour patterns. In enrichment studies locomotion decreases while groom and touch increase; in stress studies the opposite pattern is seen.

If our three arousal conditions are enrichment, and enrichment enables an animal “to respond more effectively to environmental challenges” (Novak and Suomi, 1988, p. 768), then (1) a challenge should produce stress-like changes in the four criterion behaviours, and (2) the behavioural response to that challenge should be less stress-like following our enrichment conditions than on non-arousal days. Caine’s (1988) results suggest that Callitrichid monkeys react to the entry of familiar observers as a mild threat. We use entry of an observer as a mild challenge by seeing if animals coped better on the afternoon of arousal days compared with non-arousal days. That is, was the response seen when the observer entered the animal room at a lower level in the criterion behaviours during the afternoon observations of excitement days?

ANIMALS, MATERIALS AND METHODS

Subjects and apparatus

Thirty-nine cotton-top tamarins (Saguinus o. oedipus) living in four nuclear families, at the Stirling University Psychology Primate Unit and routinely observed, were used as subjects. Each family occupied a separate room ~30 m³ in size. Each room had a covering of woodchips on the floor, shelves, sleeping boxes, and an artificial canopy of branches. A clear skylight measuring ~1×1.7 m was located above each room, and fluorescent lights were on between 07:00 and 19:00 h daily (details in Price, 1990). Family size ranged from 7 to 14 individuals, excluding dependent infants less than 1 month of age that were always carried by others and from which data was not collected.

Experimental conditions

For the bird condition a wooden model of a soaring hawk (1 m wing span) attached to a pole was repeatedly passed ~1 m above the skylight window above a family room. The model was presented 10 times at ~30-s intervals and at varying angles, speed, and direction for about 2 s each sweep.

Monkey removals were split into two types: (1) infant removals, when all newborn infants present in the family were removed with their carriers for marking; and (2) non-infant removals, when no infants under 3 months were present in the family and older animals were removed. Removal data were collected only when animal husbandry was required, such as after a birth when an infant was dye marked, when an animal reached 11 months and was fitted with an identification disc, or when a lost disc was replaced. Monkey removal
required three technicians wearing normal laboratory clothing and protective
gloves to enter the family room and catch the chosen monkey in hand nets.
The time taken to catch a monkey varied, but was ~ 5 min. When a monkey
was caught, it was removed to a treatment room within the unit, and was
separated visually from its family for about 5 min.

Procedure

A minimum of 4 days of baseline data was collected for each group for each
of the three conditions. Two data collection sessions (a.m. and p.m.) were
conducted each test day, but this report concentrates on the afternoon ses-
sions. All experimental manipulations were carried out at 10:00 h. Afternoon
data collection began 5 h after the return of the removed monkey to the group,
at 15:00 h. All sessions were divided into two halves when all individuals were
sampled once for 2 min each and then again for 3 min in the same order,
resulting in a total of 5 min per animal per session and 10 min per animal for
each test day.

Focal animal sampling at 10-s intervals was used. All baseline data collec-
tion was time-matched to the appropriate experimental conditions, and the
order of testing animals was randomized. Data were collected on all independ-
ently locomoting monkeys over 3 months of age. Each group experienced 1
infant removal and 1 bird condition, and there was a total of 20 non-infant
removals for the four groups over a period of 6 months. The four behaviour
categories were recorded at 10-s intervals: touching — when the animal was
in contact with another; low locomotion — walking or climbing; high loco-
motion — running, leaping, or jumping; and grooming one another.

Analyses

A separate analysis of variance (ANOVA) was used for each behaviour
category. The ANOVAs of the bird manipulation were of the form Condition
(2) × Groups (4) × Age (2) × Session Half (2). The ANOVAs of the two sep-
oration manipulations had the additional factor of Infant (2), present or ab-
sent. The statistical significance level was set at 0.01 throughout.

RESULTS

Arousal effects

As shown in Fig. 1, spacing was very different from baseline days ($F(3/69) = 14.7, P < 0.0001; F = 9.1, P < 0.0001$) and similar in pattern in the two
categories of removal and in the bird condition. As illustrated, activity levels
changed from baseline levels ($F(3/69) = 10.1, P < 0.0001; F = 4.8, P = 0.04$)
for both the removal and the bird manipulations, the animals spending less time in locomotory behaviour than on control days. High locomotion was reduced by over half in the excitement conditions. Grooming increased during the non-infant experimental days by 95% in comparison with only 48% and 3%, respectively, during bird and infant removal days ($F = (1/23) 12.4, P=0.001$).

The monkeys displayed a peculiar and characteristic movement pattern immediately after the removal when the animal was away, a pattern that was not observed at any other time. Typically all the animals ran in the same direction around the enclosure; they increased their inter-individual distance, and they moved in a prolonged, rapid, and jerky fashion, often only one animal moving at a time. This continued until the monkey was returned.

The results of our test conditions are similar to the effects of enrichment procedures in that both lead to increases in affiliation such as touch and groom, and to a reduction in moderate and high activity; both are dissimilar to the effects of long-term stressors such as zoo visitors and both precipitate new behaviour patterns.

Because data from the wild are not available, we cannot compare the changes recorded with behaviour under wild conditions to see if patterns are more normal.

Fig. 1. Mean difference per minute per subject from baseline in the infant removal, adult removal, and bird conditions for four behavioural categories during afternoon test sessions.
Observer effects

On the control days, the level of three of the four behaviour patterns was changed during the first half of testing, in the predicted (i.e. stress) direction when compared with the second half of testing in both the morning and afternoon tests. That is, touch and groom decreased and low locomotion increased when the observer had just entered the animal room in comparison with data taken about 20 min later when presumably the animals were less reactive to the presence of the observer. Of these three, touch and groom showed significant changes, \( F = (1/38) 6.6, \) \( P = 0.01 \) and \( F = 10.7, \) \( P = 0.002, \) respectively. The reverse direction of high locomotion casts some doubt on the use of this behaviour as a discriminator between stress and enrichment. Few other studies divide locomotion into high and low components, and so we only had one stress and one enrichment study for comparison.

In three of the four criterion behaviours the animals reacted less to the entry of the observer on those afternoons following the arousal. In comparison with uneventful control days, on arousal days touch was three times less (28% of later levels versus 10%), groom was four times less (42% versus 9%), low locomotion was two times more (7% versus 13%), but high locomotion showed an increase by a factor of two (15% versus 39%). Of the three behaviours which showed the predicted direction of experimenter-entry stress, all three showed changes in ability to cope in the predicted direction, that is, less stress effect on arousal afternoons than on control afternoons. But as none of these differences even approached statistical significance, this offers no support for the suggestion that brief arousal or enrichment experience improves ability to cope with later challenge in the short term; no support was found by Novak and Drewsen (1989).

DISCUSSION

Brief and intense arousal caused by exposure to predators and other challenges are common to all wild individuals but usually absent in captivity. We argue that analogous experiences in captivity such as we have assessed are of benefit because they are: (a) common in the wild; (b) experienced by all group members; (c) short-term arousals. That these experiences lead to both a wider range and a more normal pattern of behaviour is further argument for their benefit. We are not arguing that all wild experiences are beneficial. Being injured by a predator, being orphaned, or being physically attacked by a neighbouring group may not be of benefit, although here controlled data are not available. These wild experiences are not common, not experienced by all group members, and the resulting injuries may become long-term unavoidable stressors.

Speculation (Novak and Suomi, 1988; Chamove and Anderson, 1989) that
enrichment should lead to improved ability to cope with stressors and can be used as a measure of enrichment, appears to be based on the assumption that existing conditions are stressful, and enrichment will reduce the stress. This may be the case in severely impoverished situations or those with imposed stressors like constant visitors. Our conditions approach those of the "sem-natural" (Price, 1990), and it is less likely that enrichment under these conditions would lead to either chronic stress or improved ability to cope.

In this study, the three manipulations altered monkey behaviour in similar ways, and stimulated them to express a wider range of what we believe to be more normal behaviour, similar to patterns one would expect in the wild but are rarely seen in captivity. The characteristic vocalizations and the distinctive spacing and movement patterns were displayed only during and after the bird and the capture experiences.

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Brief Threatening Events Beneficial for Captive Tamarins?

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To evaluate speculation indirectly suggesting that brief arousal may be beneficial to animals, 39 cotton-top tamarins (Saguinus oedipus) living in 4 large families were observed (a) after normal husbandry procedures that excite them (capture and brief removal of infants or older monkeys), (b) after exposure to an overflying bird model, and (c) compared with control days in which neither of the above occurred. Both arousal conditions caused a decrease in play and locomotion, and an increase in grooming and contact during the remainder of the day. These behavioral changes are similar to the patterns reported as positive effects of enrichment but are dissimilar to negative effects of long-term stressors reported. The pattern of changes in studies of enrichment and of stress enables more objective evaluation of ambiguous events.

Key words: enrichment, primates, arousal, stress, tamarin, Saguinus, predator

INTRODUCTION

Environmental enrichment usually involves giving items to captive animals that can then be used to occupy time [Chamove and Anderson, 1988; Chamove et al., 1982; McKenzie et al., 1986; Markowitz, 1979; Rosenblum and Smiley, 1984]. These techniques result in increased affiliation, reduced moderate and high activity, and at times novel behavior patterns such as tool use [Anderson and Chamove, 1984; Chamove et al., 1988; McKenzie et al., 1986; Millar et al., 1988]. An implicit aim of this research is to interest the subjects without stressing them.

The idea that stress in captivity is always bad has been challenged indirectly by two theoretical proposals directed at suggesting a goal for enrichment. (1) Snowdon [1989, p. 149] has suggested that "animals should be maintained in captivity so that they can retain the ability to survive if they are reintroduced to the wild." (2) Chamove and Anderson [1989] argue that the goal of husbandry should be to provide conditions enabling animals to produce the full range of normal behavior in captivity, and that the mechanism for this is to "increase psychological space" by providing natural stimuli, albeit in a modified or concentrated form. The logical extension of
both these positions is that the presence of natural levels of excitement or stimulation is both desirable and essential, either to prepare the individual for future challenges or to produce normal stimuli and thereby normal behavior.

While most animal welfare researchers advocate the reduction of stress, a few suggest that low-intensity arousal may be "adaptive," and presumably, as a consequence, healthy [Dantzer and Mormede, 1983; Ewbank, 1973, 1985]. If stress is defined as "the nonspecific response of the body to any demand made upon it" [Selye, 1974, p. 27], then "stress is not something to be avoided" and "cannot be avoided" (p. 32). We feel that it is the duration of the arousal rather than its intensity that differentiates healthy from unhealthy arousal. Research results offer at least four sources of indirect support for the idea that arousal is beneficial, as long as it is brief.

First, the literature suggests that levels of arousal that are markedly and persistently lower than those likely to be found in the wild produce individuals that overreact both in intensity and duration to mild stimuli and to prolonged arousal [e.g., Garmezy, 1982; Stolba and Wood-Gush, 1980], and it appears that these individuals have difficulty inhibiting a response once a response has become probable [Chamove, 1984; Sackett, 1970]. In a variety of species, some arousal early in life enables individuals to cope better with stressors when they are older [Bovard, 1959; Chamove, 1980; Chamove and Bowman, 1978; Denenberg, 1964; Denenberg and Whimbey, 1963; Ewbank, 1973; Fox, 1986; but see Daly, 1973], especially when these are short-duration stressors.

Second, animals also appear to seek out challenge when living in captivity [Anderson and Chamove, 1984; Carder and Berkowitz, 1979; Chamove, 1986; Harlow, 1950; Inglis and Ferguson, 1985; Kear, 1961; Markowitz, 1979; Markowitz and Spinelli, 1986; Neuringer, 1970; Wood-Gush, 1973]. Several studies have shown that animals choose to work to obtain food despite the free availability of the same food and to seek out mild arousal in the form of tasks or novelty [Havelka, 1956; Millar et al., 1988].

Third, in the wild, animals have more control over certain stimulus variables and over most response variables than they do in captivity. Such control is restricted in cages; approach and withdrawal responses with respect to stimuli outside cages, withdrawal responses to stimuli within cages, and the opportunity to produce effective motor responses are particularly limited in conditions of captivity. In the wild an avoidance response can terminate a stimulus and make it "brief," while in captivity this cannot be done.

Reduction of control by being in cages is exemplified by the effects of visitors (a prolonged stimulus) on the behavior of zoo animals [e.g., Glatston et al., 1984; Hosey and Druck, 1987]. Recent research suggests that visitors change the behavior of monkeys in a way similar to that caused by other mild but long-term stressors [Chamove et al., 1988]. The presence of visitors is associated with increases in activity and abnormal behavior, and with decreases in inactivity, grooming, and affiliation.

Fourth, cages limit the range of behavior shown by an animal. Several lines of research have shown that increasing the range of foods eaten [Kirkwood and Dow, 1986], increasing the range of muscles used [Turnquist, 1986], and increasing the range of stimuli to which one is exposed are all healthier [Bollhorn, 1980; Ekesbo, 1981; Fox, 1986; Gross, 1972; Kendrick, 1972; van Putten and Dammers, 1976; Renner and Rosenzweig, 1987; Riley, 1981]. Therefore, one would predict that
arousal, by introducing a new category of stimuli and perhaps new responses, would increase health.

In sum, we hold that the literature supports the following process. Novel, exciting, or threatening stimuli lead to arousal. If these stimuli are eliminated after a short period, then the arousal is reduced, there is no stress response to the arousal, and (because the pattern of stimulation is similar to that found in the normal, non-captive condition) the animal benefits. On the other hand, if these stimuli are prolonged, and the arousal maintained, there is what is commonly understood as stress (because the pattern is dissimilar to that experienced when in the wild): the animal’s coping/adaptation response is exhausted, and it enters what Selye [1974] has termed the stage of adrenal depletion. Mild stimulation, if aversive and prolonged, can become a stress; strong stimulation, if brief and not repeated, will not act as a stress.

In this study we observed the behavior of four large tamarin families on days during which three types of arousing experiences occurred and compared it to behavior on days with typical uneventful laboratory experience [Line et al., 1989]. The excitement was in the form of normal laboratory experience, only presented in a controlled manner. We then assessed whether brief excitement is beneficial for laboratory-housed monkeys by comparing resulting changes with behavior change produced by long-term stressors and by environmental enrichment.

MATERIALS AND METHODS

Subjects and Apparatus

Thirty-nine cotton-top tamarins (Saguinus o. oedipus) living in four nuclear families at the Stirling University Psychology Primate Unit and habituated to observation were used as subjects. Each family occupied a separate room approximately 3 \times 3.5 \times 3 m, 30 m$^3$. Each room had a covering of woodchips on the floor and an artificial canopy of branches and was furnished with sleeping boxes, shelves, and swings. A clear skylight measuring approximately 1 \times 1.7 m was located above each room, and fluorescent lights were on between 0700 hr and 1900 hr daily. Details of feeding and husbandry are available from McKenzie et al. [1986]. Family sizes ranged from seven to 14, excluding dependent infants less than 1 month of age that were always carried by others. Adults and sub-adults were identified by colored discs worn on necklaces, and juveniles and infants by yellow dye marks on their heads. In two families the breeding pair were wild caught; in the other two the parents were captive bred.

Experimental Conditions

For the bird condition a wooden model of a soaring hawk (1 m wing-span) attached to a pole was repeatedly passed about 1 m above the skylight window above a family room. The model was presented 10 times during a period of 5 min at varying angles, speed, and direction. For each family the bird condition was carried out on separate days, and adjacent rooms were never tested on consecutive days.

Monkey removals were split into two types: (1) Infant removals—when all newborn infants present in the family were removed with their carriers for marking, and (2) non-infant removals—when no infants under 3 months were present in the family and older animals were removed. Removal data were collected when animal husbandry was required, such as after a birth when an infant was dye marked, when
an animal reached 11 months or 500 g and was given an identification disk for the first time, or when a disk was lost. The monkeys were only caught for reasons of husbandry.

Monkey removal required three primate unit technicians’ wearing normal laboratory clothing and protective gloves. The three entered the family room and using handnets caught a chosen monkey for marking or collaring. The time taken to catch up a monkey varied, but was around 5 min on average. When a monkey was caught, it was removed to a treatment room within the unit and was separated from its family for about 5 min. It is likely that the family could hear its calls during most of this period.

These conditions were chosen for study as (1) they occurred normally in the laboratory, (2) appeared to visibly excite the monkeys, and (3) could be controlled.

Procedure

A minimum of 4 days of baseline data was collected for each group for each of the three conditions. We believed that baseline data with dependent infants might be different from those without infants present in the group. Two data collection sessions (AM and PM) were conducted each test day. All experimental manipulations were carried out at 1000 hr with the morning session beginning 15 min after the return of the removed monkey to the group, or 15 min after the end of the bird presentation. Afternoon data collection began 4 hr later at approximately 1500 hr. All sessions were divided into 2 halves when all individuals were sampled once for 2 min each and then again for 3 min in the same order, resulting in a total of 5 min per animal per session and 10 min per animal each test day. The half factor was included to remove any variance owing to the entry of the experimenter into the room for data collection.

Focal animal sampling at 10 sec intervals was used. All baseline data collection was time-matched to the appropriate experimental conditions, and the order of testing was randomized throughout. Data were collected on all independently locomoting individuals over 3 months of age. Each group experienced one infant removal and one bird condition. There were a total of 20 non-infant removal experiences for the four groups over a period of 6 months. The frequency of the manipulations was constrained by normal husbandry routines and the fact that these monkeys give birth at 7-mo intervals.

Four behavior categories were recorded at 10 sec intervals, and a fifth was recorded whenever it occurred. (1) Spacing behavior (inter-subject spacing) was categorized into four distance intervals, when the nearest animal was in contact, at arms length, a meter away, or greater than a meter distant [see also Chamove and Anderson, 1989; McKenzie et al., 1986]. (2) Total activity levels were also divided into four categories: stationary, when the focal animal was inactive and still, e.g., sitting; active, when the animal was stationary but active, e.g., manipulating or interacting with either the environment or another individual; locomotion, e.g., walking or climbing; and high locomotion, including running, leaping, or jumping. Interval data were also recorded for (3) social grooming, and (4) social play. (5) Scratching behavior in the focal subject was recorded whenever it was observed because it is reported to increase when monkeys are mildly aroused [Diezinger and Anderson, 1986]. Abnormal behavior never occurred, and aggressive behavior occurred so rarely in our colony [Millar et al., 1988] that these were not recorded.
Analyses

A separate analysis of variance (ANOVA) was used for each of the five behavior categories—spacing, activity, scratching, grooming, and playing. The ANOVAs of the bird manipulation were of the form condition (2) × groups (4) × age (4) × time (2) × half (2). The ANOVAs of the two separation manipulations also had the factor of infant (2), present or absent. The factors of groups, age, and half were used to remove variance rather than because of an interest in these factors. The statistical significance level was set at .01 throughout.

RESULTS

During the remainder of the day on which the experimental conditions occurred, the monkeys were found to locomote less and to be less playful and more stationary; they also groomed and scratched more. Immediately after the manipulations, they were spaced more widely, and later in the day they were spaced more closely than normal. There was a non-significant tendency for removal of infants to have less effect than removal of older group members.

Spacing

It was noticeable that during the 5 min of the experimental phase, the monkeys were more widely spaced from one another than usual. This spatial separation was maintained after the manipulation period and during the first data collection period in the morning and was largely responsible for the total day increase in the distance category. As shown in Figure 1, spacing was different from baseline days (F(3/69) = 14.7, $P < .0001$; $F = 9.1, P < .0001$) in both removal and bird conditions in the condition × behavior interaction. The amount of time spent at the 1-meter spacing
category decreased in both the morning and afternoon sessions, especially in the latter. Increase in the closest spacing category, touch, was apparent only in the afternoon session. These day/time spacing patterns were similar in both types of removals and in the bird condition, and similar to that reported by Glatston et al. [1984].

Activity

As illustrated in Figure 2, activity in the two test sessions changed from baseline levels ($F(3/69) = 10.1, P < .0001; F = 4.8, P = .04$) for both the removal and the bird manipulations in the condition $\times$ behavior interaction. The animals spent more time stationary especially in the morning and less time in locomotory behavior than on days without the excitement. The pattern of increase in inactivity was similar in both bird and removal situations. High locomotion reduced by 50% and 56% in the removal and bird conditions respectively, while time stationary increased by a comparable amount.

Scratch

The only significant change was a 54% increase in scratching during non-infant removals compared with an increase of only 12% and 13% during infant removals and bird days. This was shown by an interaction of condition $\times$ infant ($F(1/35) = 6.4, P = .01$) in the removals ANOVA (see Fig. 3 left). The greater effect was in the morning test session.

Groom

Grooming showed a similar pattern to scratching, increasing during the non-infant experimental days by 95% in comparison to only 3% and 48%, respectively,
Fig. 3. Difference from baseline in the 3 experimental conditions for the three behaviors—groom, play, and scratch—separating morning and afternoon test sessions.

during infant removal and bird days ($F = (1/23) 12.4, P = .001$). The overall increase (see Fig. 3, center) was solely due to large increases in grooming in the afternoon session, whereas in the morning session, grooming was reduced from baseline.

**Play**

Although play did not change during the bird condition, it decreased in the two removal conditions ($F = 18.0, P = .0003$) by an average of 61% (see Fig. 3, right). This change was greatest in the juvenile monkeys who played the most during baseline and least in adults who rarely played; play reduced by 75%, 55%, and 39% in the juveniles, sub-adults, and adults, respectively. The reduction in play was greatest in the morning session for all conditions but increased in the afternoon in the bird condition for all sub-groups except the juveniles.

The monkeys displayed a characteristic movement pattern immediately after the removal when the animal was away, a pattern that was not observed at any other time. Typically all the animals ran in the same direction around the enclosure; they increased their inter-individual distance, and they moved in a prolonged, rapid, and jerky fashion, often only one animal moving at a time. This continued until the monkey was returned.
Moodie and Chamove

TABLE 1. Significant changes (non-significant changes are in parentheses) from baseline in behavior from five studies of enrichment, from the present study, and from three studies involving stress, all using non-anthropoid primates*

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aPlay results are for juveniles and sub-adults who play the most; adults showed the opposite effects. Like the present study, the four numbered studies 3, 4, 6, and 7 (in bold) all used callitrichid monkeys. +, Increase from baseline. -, a decrease. =, no change.

DISCUSSION

Brief arousal caused by exposure to predators and other challenges is common to all wild individuals and is often absent in captivity. Analogous experiences in captivity such as we have assessed are arguably of benefit solely because they are (a) common in the wild, (b) experienced by all group members, and (c) are short-term arousals. That these experiences lead to both a wider range and a more normal pattern of behavior is further argument for their benefit. We are not arguing that all wild experiences are beneficial. Being injured by a predator or being physically attacked by a neighboring group may arguably not be of benefit. These wild experiences are (a) not common, (b) not experienced by all group members, and (c) the resulting injuries are likely to become long-term unavoidable stressors.

Brief arousal caused by what could be a potential predator is analogous to conditions that these monkeys would experience in the wild. The three conditions altered their behavior in similar ways and stimulated them to express what we believe to be a more normal and a wider range of behavior, which may mimic patterns one would expect in the wild but are rarely seen in captivity. The characteristic vocalizations and the peculiar spacing and movement patterns were displayed only during and after the bird and the capture experiences.
As summarized in Table 1, the results of our test conditions are similar to the effects of enrichment procedures in that both lead to increases in affiliation such as touch and groom, a reduction in moderate and high activity, and apparently new behavior patterns. Because data from the wild are not available, we cannot compare the changes recorded with behavior under wild conditions.

The behavior changes in the monkeys are dissimilar to the effects of long-term stressors, such as zoo visitors, which lead to reductions of inactivity, grooming, affiliation, and in the range of behavior. It might be expected that if brief exposure to challenging events was harmful, then behavior might show similarities to the reported effects of long-term stressors. There are some indications that the behavior immediately after the manipulations resemble in a few ways behavior change similar to stressors, but these effects are few and appeared transient. It is the afternoon changes from baseline in which we were most interested.

We should emphasize that, because we could find no others, the comparison measures chosen from the literature were those taken during the stress and during the enrichment and while the animals were responding to the stimuli. In this study measures were taken after the arousal experience. This difference may lead to problems of comparison and interpretation. In the present study inactivity increased after all conditions, while it decreased during both stress and enrichment conditions. This could be because enrichment commonly requires or encourages activity. But we believe that when the pattern of changes is compatible with both enrichment and stress studies, it gives support for our argument.

Alternatively it might be suggested that the reduced activity after excitement may have been merely a reaction to the increased activity during excitement. In support of this position, there is evidence that monkeys maintain a stable level of certain activities throughout a day, although varying the direction and type of activity [e.g., Chamove, 1973]. It appeared that the level of activity during capture was very much higher than usual, and was of a different type as well. Moreover, activity level when given the over-flying bird silhouette was not high (Fig. 4), and was similar to that described for released tamarins—alarm chirps, initial rapid and brief escape to cover, and increased spacing, followed by investigative approach toward the skylight approximately midway thorough the 5-min bird presentation period [see Kleiman et al., 1986]. The behavior changes that occurred later in the day were similar across the three conditions, and cannot be attributed solely to changes in activity level during excitement.

Because the brief excitement is "natural," because it increases the variety of behavior, and because subsequent behavior is more similar to that seen in enriched conditions than in long-term stressful conditions, we conclude that brief stimuli that cause initial reactions of fear or other sorts of "negative" arousal are beneficial to monkeys in a laboratory setting.

ACKNOWLEDGMENTS

Fig. 4. Exploratory response of tamarins to the bird silhouette.

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Contact & Attachment


SEX DIFFERENCES IN THE INFANT-DIRECTED BEHAVIOR OF PREADOLESCENT RHESUS MONKEYS

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University of Wisconsin

15 pairs of preadolescent rhesus monkeys, matched for rearing experience were tested with a 1-month-old infant. Preadolescent females directed significantly more positive social behavior (p < .05) and significantly less hostility (p < .01) toward the infant than did males. These results are taken as evidence that hormonal changes at puberty are not the only variables producing sex differences in infant-directed behavior.

From the reports of field studies, there is evidence that infant-directed behavior differs between the sexes both in adult and preadolescent primates (for the baboon, DeVore, 1963; for the macaque, Itani, 1959; for the langur, Jay, 1963; and for the gorilla, Schaller, 1963). The greater interest of immature females than immature males in the newborn infant is evident at an age of 6 months or less in the chacma baboon (Bolwig, 1959). That these sex differences are not invariant is illustrated by reports of paternal behavior in the adult macaque (Itani, 1959).

Sex differences have been reported in preadolescent monkeys in the laboratory with respect to peer interaction (see Harlow & Harlow, 1965 [based on data by Hansen, 1962; Rosenblum, 1961]). However, there have been no comparisons of male and female juveniles with regard to infant-directed behavior in the laboratory. The present study was designed to measure sex differences in preadolescent-infant interactions. It was suspected that sex differences in infant-directed behavior would be present before the advent of the hormonal changes of puberty.

This research was supported by USPHS grants MH-11894 and FR-0167 from the National Institutes of Health to the University of Wisconsin Primate Laboratory and Regional Primate Research Center, respectively. Author Harlow’s address: University of Wisconsin Primate Laboratory and Regional Primate Research Center, 1223 Capitol Court, Madison, Wisconsin 53706.
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METHOD

Subjects

One female infant rhesus monkey between the age of 20 and 40 days was used as a stimulus animal, and 30 preadolescent rhesus monkeys were used as Ss in this study. The 30 Ss were 15 male-female pairs (18–30 months). The pairs were matched for age, type of social rearing, and tester (E). All of the preadolescent pairs had prolonged social experience from birth. The type of social experience varied between, but not within, the matched pairs. Of the 15 pairs, 7 experienced only peer interaction; 4 received primarily maternal experience with little peer interaction; and 4 other pairs had both maternal and peer experience.

Apparatus

The Ss were individually tested with the stimulus infant in a playpen apparatus modified from one described by Seay (1966) and illustrated in Figure 1. A center area, the combined playpen units of the original apparatus (see Harlow & Harlow, 1965, p. 297), for infant adaptation measured 60 X 60 X 60 inches. The four living cages (36 X 36 X 36 inches)
for the preadolescents housed two sets of adjacent pairs on opposite sides of the center area. The walls, floor, and roof of the center area and living cages were made of 0.120-inch steel wire mesh with 1-inch openings in the sides and tops and ¾-inch openings in the floors. A 36 × 36 inch sheet of Masonite prevented adjacent pairs of preadolescents from viewing one another and directed their attention toward the infant in the center during adaptation. Another 36 × 36 inch Masonite sheet was inserted between each preadolescent’s living cage and the center area during individual testing.

Procedure

The infant was housed in the center area throughout the experiment. The two monkeys of a matched pair were placed in adjacent living cages and allowed to see the infant for a 24-hour adaptation period. After adaptation, the second Masonite panel was inserted, and testing was begun. Two pairs of preadolescents were adapted and tested each day.

Before testing, the infant was transferred by hand to one of the living cages. As soon as the door was shut (a matter of 10–15 seconds), the E sat down, turned on a session timer and began recording behavior. Each session lasted 15 minutes. There were two Es, and both members of the same matched pair were tested by the same E; E1 tested seven pairs and E2 tested eight pairs.

The recording apparatus was a bank of nine clocks. Nine micro-switches activated these clocks each time they were depressed by the E. The clocks recorded durations of nine behaviors. One category measured infant-initiated contact; the other eight categories were infant-directed behaviors by the preadolescent and included: (a) ventral contact and/or embrace, (b) sexual behavior, (c) grooming and lipsmacking (maternal-related behaviors), (d) visual orientation, (e) fear or disturbance, (f) play, (g) hostility, and (h) all other physical contact with the infant. In addition, categories (a), (b), (c), (f), and (h) were combined to provide a measure of the total positive social behavior directed toward the infant.

The Wilcoxon matched-pairs, signed-ranks test (Siegel, 1956, p. 75) was applied to the matched-groups comparisons. A two-tailed test was used, and differences occurring with a probability of less than .05 were accepted as statistically significant. A Mann-Whitney U tested the E differences and a Kruskal-Wallis test examined differences between the three types of rearing.

RESULTS

Quantitative results

Hostility and total positive social behavior were the only categories which revealed statistically significant differences between males and fe-
males. As is clearly shown in Figure 2, females directed four times as much positive social behavior toward the infant as did the males ($p < .05$). Hostility toward the infant, on the other hand, appeared to be almost exclusively a male characteristic, with males exhibiting ten times more hostility than females ($p < .01$). There were no significant differences between the two Es or between rearing conditions.

![Positive Social Behaviors and Hostility Chart]

**Fig. 2.—**Infant-directed behavior of preadolescent monkeys

**Qualitative results**

The infant was disturbed by being placed in a preadolescent’s cage only during the first 20 or 30 seconds. She actively explored and initiated contact with 24 out of the 30 Ss. There appeared to be no relationship between the amount of maternal behavior by the preadolescent and the number of contacts initiated by the infant.

There were large individual differences in the behavior of the preadolescents. Three of the 15 males and 5 of 15 females established ventral contact with the infant, one of the females for nearly half a minute. Five of the 15 males and 10 of 15 females exhibited other maternal relevant behaviors (lip-smack and groom).

There were no sex differences in visual orientation toward the infant. Twelve of the thirty subjects directed sexual behavior toward the infant, and both male and female postures were observed in both sexes. Although
the female subjects played more often with the infant than the males did, the differences were not significant. (In another study these same preadolescent males were much more playful than the females when placed with peers.) One female was extremely frightened by the infant. Although the infant made three attempts at contact, the older female withdrew each time and grimaced with fear. This same female looked at the infant only once; the rest of the time she sat huddled in a corner with her back to the infant. While 14 other preadolescents were mildly disturbed for a small fraction of the test session, none showed the extreme fear seen in this one female.

Only 4 of 15 females threatened the infant and no female aggressed, whereas 13 males threatened and/or aggressed. The male aggression was brutal only once when a male bit off one of the infant's fingertips; the session was terminated at 7½ minutes. The infant was given one week to recover from the incident and showed no disturbance upon resumption of the test session.

All of the females, with the exception of the extremely frightened one, contacted the infant, whereas only two of the males did so. Many of the preadolescents, mostly females, threatened the E, and two females retrieved and embraced the infant for several seconds as the E tried to remove it. Ironically, these last two females ignored the infant throughout most of the test session, accumulating an amount of positive social behavior which was far below the female average.

DISCUSSION

The results indicate that there are basic sex differences in the infant-directed behaviors of immature monkeys just as there are in such peer-directed activities as mounting, sexual presenting, play, and hostility (Harlow & Harlow, 1965). Such differences were present both in monkeys that were reared with only a mother and in monkeys reared with only a peer. Early sex differences have been observed in monkeys over a wide range of social-rearing conditions at the Wisconsin Primate Laboratories, and the results suggest that while some critical amount of social experience seems necessary for the appropriate occurrence of positive social behaviors (Mitchell, Raymond, Ruppenthal, & Harlow, 1966), the experience does not have to be with infants. In the present study, the preadolescents had either no previous experience with newborn infants at all or else had such experiences only when they themselves were infants.

In humans, a biologically oriented attitude toward sex differences is usually either ignored or only briefly mentioned (Scheinfield [1950; p. 519] is an exception). It is generally believed that sex differences are to a large extent culturally determined by a process called “sex-typing” (see Mussen, Conger, & Kagen, 1963, p. 286). No one will question that cultural vari-
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ables in the human being greatly influence recognition and acceptance of sex role and sex typing, and these roles in turn affect the attitudes of human adults towards babies and infants. However, the data of the present experiment present unequivocal evidence that biological variables in monkeys also significantly influence adolescent responses directed toward infants, that is, maternal-type behaviors. To a considerable extent, cultural variables can override biological variables in the human being (Hampson & Hampson, 1961), but the relative importance of these two factors in various developmental stages remains unresolved.

The present experiment gives no direct evidence concerning the neural or hormonal mechanism producing differential attitudes in preadolescent and adolescent monkeys toward neonates or infants. It is possible that there are sex-specific neural mechanisms in monkeys and that these biological systems are primary to the characteristic behaviors of the sexes. Support for such a position is found in the early appearance of differential play, sex, dominance, and submissive patterns (Harlow & Harlow, 1965) at a time when hormonal systems specific to the two sexes either do not exist or have not yet been identified. It is possible that the preadolescent males and females in the present study may already have sex-specific hormonal systems and that these could be variables of measurable importance. If this is true, the effects reported may be produced either by sensitization of one neural mechanism which is different in the preadolescent male than it is in the female or conceivably by a differential sensitization of two different neural mechanisms which appear in both the preadolescent male and female.

The primary contribution of the present study was the identification of differential infant-directed response patterns in sexually immature male and female monkeys. The females typically exhibited maternal-like affiliative patterns towards infants, whereas the males exhibited patterns of indifference or hostility. The identification of these differential patterns provides a behavioral base for correlative neurological and hormonal investigations, even though such studies are beyond the scope of the present paper.

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Social Behavior Comparison in Laboratory-Reared Stumptail and Rhesus Macaques

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Abstract. No differences in social behavior during the first year of life were found in comparisons of two quadrats of each macaque type when controlling for adult-related differences by rearing infants with one another. No support was found for reports of feral stumptails being more affiliative or less assertive. Another group of rhesus tested in a larger enclosure were more assertive and more fearful when compared with rhesus in a small test cage.

When comparing the stumptail (Macaca arctoides) with the rhesus (M. mulatta) macaque, the former is generally considered more gentle toward humans and more adaptable to test apparatus [Schrier, 1967]. Bertrand [1969] hypothesizes that the well developed opportunism of stumptails, as evinced in redirection of aggression and fluid alliances, may cause them to tame more quickly (p. 108), although elsewhere (p. 109) she states that the even tamer lontail macaque (M. silenus) redirects less often than does the stumptail.

Others [Blurton-Jones and Trollope, 1968], discussing this hypothesis, feel instead that ‘part of the apparent docility may derive from a freezing or at least a silencing response to danger’ (p. 391). They attribute this to the more arboreal nature of the stumptail when compared with rhesus. One might suggest that, aside from these superficial responses to external stimuli, the two macaques are quite similar.

As stumptails are more arboreal than rhesus, one might expect them, therefore, to be more affiliative, although the closely related and arboreal pigtail (M. nemestrina) appears less affiliative than the more terrestrial bonnet macaque, M. radiata [Rosenblum, 1971]. Also the distinctive natal
coat color of the stumptail might be expected to correlate with behaviors different from those of other macaques with a less distinctive infant color, perhaps inhibition of aggression additional to their diminutive size. Stumptail males are more paternalistic, or more sociable toward infants than rhesus, but not more than bonnet or crab-eating (*M. fascicularis*) macaques which do not have the distinctive natal color [Brandt et al., 1970].

Published comparisons of *M. mulatta* and *M. arctoides* have, without exception, used feral animals, captured and acclimatized to the laboratory. Seven such primates were compared in a cage using adjacent stimulus animals by Davis et al. [1968]. They report their five stumptails as exhibiting more behavior rated as social, social grooming, and coo-vocalization; and less inanimate, social observation, and bark than did the six rhesus. This proclivity for grooming has been supported by others [Goosen, 1971]. Boelkins [1967] reports only a slightly more flexible drinking order in stumptails when compared with pigtails. Contrasting grooming patterns in these same subjects [personal commun., 1965], he notices that stumptails, when compared with pigtails, groomed more and also groomed relatively more those animals above them in the dominance hierarchy, especially when the recipient was three to nine positions above them. Whereas pigtails groomed subordinates 83% as frequently as they groomed dominants, stumptails only groomed subordinates 49% as frequently as they did animals ranked above them. In the pigtails the total duration of grooming a less dominant monkey was 64% of that of grooming a more dominant; whereas in stumptails the comparable figure was 32%. These results suggest that stumptails are more friendly towards superiors, perhaps more opportunistic.

Sackett [1970], testing preferences in three macaque species, found no differences in the relative preferences of stumptails, pigtails, and rhesus, each preferring their own species to either of two others by a factor of just over two.

Comparing group formation in four macaque species, rhesus were more agonistic overall. Stumptails showed daily increases in agonistic, grooming, and self-directed behaviors and decreases in contact, unlike that found in the rhesus group [Hawkes, 1971]. The low initial aggressive level during group formation was supported by Rhine and Kronenwetter [1972].

The differences reported may have been due to a variety of factors – response to capture, cultural or learned differences, or genetic differences. The present study compares the social behavior of a group of four stumptails with two groups of four rhesus. All were separated from adults at birth and raised in such a manner as has been shown to produce adequate social
Development. None of the subjects had had opportunity to learn species-specific behaviors from feral or adult monkeys. As rhesus may be less social animals, one of the two rhesus groups was tested in a larger enclosure, believing that perhaps the expected aggressiveness of the rhesus might be modified by that larger enclosure. We hypothesized *M. arctoides* to be more affiliative, less assertive than *M. mulatta*.

**Method**

4 male *M. arctoides* and 8 male *M. mulatta*, conceived and born in the laboratory, were separated from their mothers within 24 h of birth and raised alone in wire mesh cages with a soft white cloth. Animals were hand-fed for less than two weeks, subsequently being fed a milk diet, Similac, every four hours from drinking bottles. These animals formed three groups: stumptail, rhesus 1, and rhesus 2. Starting at three months of age, animals were paired six days a week in their homecages for over 2 h in the early evening. The pairing was within groups and cycled so that every animal within a group was paired with each of the other three twice a week. These stainless steel wire mesh homecages measured $0.46 \times 0.61 \times 0.61$ m.

Testing took place twice a week in the afternoon. All four animals of a group were removed either to the test cage in another room (groups stumptail and rhesus 1), or to an adjoining playroom (group rhesus 2). The test cage measured $0.9 \times 1.8 \times 0.9$ m and was stainless steel wire mesh. The playroom was almost three times larger, $3 \times 3 \times 3$ m with a large $1.5 \times 3$ m and a small $0.5 \times 3$ m mesh platform, a mesh swing, a ladder, and a rubber hose. The experimenter was within six ft of the test apparatus and in full view of the animals.

One experimenter observed each animal during two 5-min test sessions. He recorded the duration of the following behaviors on a bank of nine clocks [described by Chamove et al., 1972]: **positive contact** - any physical contact other than that of fear or hostility; **negative contact** - hostile contact; **hostile** - any aggressive behavior; **immobility** - subject exhibiting nonspecific withdrawal into a corner or into a huddle; **appropriate fear** - withdrawing from or submission to a hostile monkey; **inappropriate fear** - withdrawing from or submission to a fearful, exploring, or playing monkey; **visual explore** - watching other animals; **social play** - playing with other animals; **nonsocial play** - nonstereotyped vigorous activity directed towards the self or an inanimate part of the environment.

Animals were tested for nine months, until one year of age. Three repeated-measures analyses of variance were used to evaluate the results. All used the three monkey groups and two blocks composed of the first three- and second six-months of data with blocks as a repeated measure. The first analysis used three levels of behaviors (visual explore, social play, and nonsocial play) which were correlated variables. The second analyzed appropriate and inappropriate fear and immobility as three levels of behaviors. The final analysis used four behaviors dichotomized into positive and negative and into contact and noncontact behavior. These were positive contact, negative contact, social play and hostile. This final analysis was a 3 (groups) $\times$ 2 (blocks) $\times$ 2 (positive-
negative) × 2 (contact-noncontact) set up. All group interactions had 2 and 9 degrees of freedom.

Subsequent Fisher's LSD tests [1967] enabled prior significance to be delineated.

**Results**

As can be seen in figure 1, there were few differences in the behaviors between rhesus and stumptail monkeys. Those differences emerging from the analyses can be attributed to the assertive (play and negative contact) nature of the rhesus 2 monkeys and their high level of fear exploration, and positive contact (probably huddling or clinging together in the second block). This was seen in a significant overall group effect in the first analysis ($F = 134.0$),

![Diagram of behaviors recorded during first three and second six months of testing.](image)

*Fig. 1.* Behaviors recorded during first three and second six months of testing.
reflecting rhesus 2 as highest in these three behaviors and a three-way interaction \((F = 7.7)\). Also seen was a significant group \(\times\) blocks \(\times\) contact-noncontact interaction in the third analysis, interpreted as rhesus 2 exhibiting more social play and hostility in block 1 and contact in block 2 \((F = 135.5)\). The only other group interaction to reach significance was the three-way interaction in analysis two \((F = 15.6)\), but inspection of the raw data indicates that again it is rhesus 2 that is the more aberrant in block 2, showing more immobility and a significant increase in inappropriate fear over the two blocks.

We conclude that the stumptail is not so different from the rhesus as data collected from captured animals would suggest. His tameness is not reflected in his disposition toward peers, at least not within the first year of life. The differences reported by other investigators can be accounted for by rearing differences similar to those reported for bonnets and pigtails by Rosenblum [1971], or by the generally greater age of animals used by others, or by interaction of the two.

**Summary**

Three groups of four monkeys each were reared from birth having had social experience only with one another. No support was found for reports that feral stumptails are more affiliative or less assertive than rhesus macaques. In fact, no significant differences could be found in their social behavior. An attempt to reduce expected *M. mulatta* aggressiveness by increasing enclosure size was counterproductive.

**Acknowledgements**

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MONKEYS (MACACA MULATTA) RAISED ONLY WITH PEERS.
A PILOT STUDY

BY A. S. CHAMOVE,* L. A. ROSENBLUM,† & H. F. HARLOW

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Abstract. Four infant rhesus raised in a group (4-TT) and six raised in pairs (2-TT) were compared with eight infants raised on mother surrogates (SP) and twenty raised with real mothers (MP). When tested with peers early in life 4-TT and 2-TT subjects showed less play, hostility and sex, and the 2-TT subjects exhibited a preponderance of social clinging. When tested as adults the 2-TT and 4-TT monkeys were below controls on measures of play, above controls on social proximity, hostility, and withdrawal, and the 2-TT subjects showed inadequate sexual adjustment. Data are interpreted as suggesting that behaviours normally associated with affectional ties can become so extreme as to inhibit normal social development.

During the past decade research on the effects of various rearing conditions on the social development of monkeys has generally emphasized the first 6 months of life as a period of extreme importance for the subsequent development of normal adolescent and adult behaviour. These investigations in which monkeys were subjected to different mothering conditions or given varying opportunities to form early age-mate attachments suggest that the opportunity to form effective patterns of social interaction early in life is of prime importance for the formation of normal age-mate affectional bonds prior to adulthood and, subsequently, the development of adequate social adjustments as adults (Harlow & Harlow 1965).

The most limited opportunity for learning social interaction patterns is achieved by separating infant monkeys from their mothers at birth and rearing them in an isolation situation where they are denied both visual and bodily contact with any mother and any other infants. This form of deprivation, described as total social isolation, has been systematically studied at the Wisconsin laboratories for periods ranging from birth to 3 months, 6 months, 9 months, 12 months, and 18 months (see Sackett 1968). Although such deprivation produced no effect on growth or general bodily health (Kerr, Chamove & Harlow 1969), isolation throughout the first 6 months of life resulted in somewhat circumscribed and probably permanent social deficits; isolation from birth to 9 or 12 months produced short-term social debilitation and dramatic long-term deficits (Harlow et al. 1966; Mitchell et al. 1966).

Under more normal rearing conditions the first affectional system which develops is the mother-infant affectional system which functions both to give the infant a base of security while he explores his environment and presumably to restrain him from involvement in injurious or fear-producing situations. The mother may also teach the infant specific social interaction expectancies or patterns (Hansen 1966) that, subsequently, may be generalized to other members of the same or allied species. As this maternal affectional system gradually develops from the primary stage of attachment into the secondary stage of maternal ambivalence (starting at about three months in the laboratory, Hansen 1966), the actions of the mother may become a factor encouraging emancipation of the infant from continued orientation to the mother and thus facilitate interaction with the external environment and with other infants and thereby encourage the formation of diffuse infant-infant affectional relationships (Harlow & Harlow 1965).

Whereas the normal mother adequately provides the stimuli for the first affectional system, an inanimate mother surrogate does not. Animals raised on cloth mother surrogates accept this object as a source of maternal comfort and security, but they cannot receive any form of maternal social interaction, including early maternal restraint or later maternal rejection. Initially, subjects reared in this manner

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Although time in contact with the surrogate decreased with age after 3 months, the surrogate-reared subjects spent more time in contact with their mother surrogate and were less socially oriented toward peers than mother-reared subjects. The present study was designed to measure a form of partial social privation in which infant monkeys were deprived of any form of mothering and yet permitted extensive opportunity for age-mate (i.e., peer) interaction. We studied two types of motherless situations: one in which infants were raised in pairs and the other in which they were raised in groups of four. Because of the intense clinging responses of peer-reared subjects, we refer to these groups as the 2-together-together (2-TT) and the 4-together-together (4-TT) monkeys.

Methods

Subjects

The monkeys (Macaca mulatta) utilized in the present investigation were divided into three primary experimental groups. These three experimental groups consisted of the following: (1) four infants, three of which were female, raised in a group of four called the 4-together-together monkeys (4-TT), (2) four female infants raised in pairs called the 2-together-together monkeys (2-TT), and (3) two sex-balanced groups of four infants each raised with surrogate mothers and interacting peers, and called the surrogate-peer (SP) groups.

These groups were compared to a fourth group of twenty monkeys. This comparison group was formed from five sex-balanced groups of four subjects each raised by monkey mothers and provided with interacting peers, called the mother-peer monkey (MP) groups. These data, added for illustrative purposes, should be viewed with several cautions in mind. The data were collected over a period of 9 years by pairs of experimenters, one of which overlapped throughout that period and was therefore believed to be able to give stable and generalizable data. The categories evolved throughout that time, but the aggregates used here are believed to have suffered little modification. The major difference is that all MP subjects were tested in dyads in a playpen using 15-s instead of 30-s intervals. All of the MP data were converted so that the total possible score was comparable to that of TT and SP groups. A comparison of two SP groups tested using 30-s intervals in the playroom (reported in Rosenblum, 1961) and another SP group tested using 15-s intervals in the playpen in pairs (reported in Hansen, 1966) yielded remarkable correspondence, and formed the basis for inclusion of MP data although all MP monkeys were tested in a playpen. We stress that the MP comparisons are only illustrative, but surely cannot detract from the basic 2-TT, 4-TT and SP findings reported here.

There was in addition to these four longitudinally tested groups a special pair of female 2-TT monkeys. This latter pair was observed at different times and on different tests to supplement the information obtained from the major experimental groups and was called the special 2-TT group.

Test Apparatus and Procedure

In brief the subjects from the 2-TT, 4-TT and SP groups were socially tested for the first 6 months of life in infant groups of four, while the MP subjects were tested in groups of two. All subjects were tested in the presence of their 'mother' or 'security' figure. Subsequently, the monkeys of the 2-TT dyads were cross-paired to test the specificity of infant-infant or together-together clinging. From 1 year of age onward all monkeys were individually housed for several years, and the sexually mature females were then tested as follows: (1) with sophisticated male animals to assess sexual adequacy, and (2)
for those that were successfully bred, with their own infants for adequacy of social response. The specific details of each phase of the social testing were as follows.

Infant Housing

During the first year of life the six 2-TT subjects from the 2-TT and special groups were housed as pairs, each member designated as the peer-partner of the other, each pair housed in a wire mesh cage 0.38 × 0.46 × 0.61 m. The eight surrogate-peer (SP) animals were housed individually in dual surrogate booths (Harlow 1969) measuring 0.61 × 0.61 × 0.61 m with free access to a cloth and wire surrogate. The four 4-TT animals were housed in a 0.71 × 0.71 × 1.82 m dual cage enclosure described by Alexander & Harlow (1965). The mother-peer (MP) groups were raised and socially tested in groups of two in playpen units, cages where each mother and infant lived paired in one compartment, the living area. However, the infants could leave each individual unit through a door small enough to exclude the mother and interact with a single other infant in a central play area. This door was opened once or twice a day for 20 min each time. Between 12 and 15 months of age all subjects were housed individually.

Infant Testing

Infant social testing of the three primary experimental groups was carried out in playroom I (Harlow & Harlow 1965) which was an irregular hexagon 2.45 m high, with approximately 4.1 m² of floor space. The room contained two cloth surrogates and various manipulanda, including inclined mesh ramps, ladders, Plexiglas tunnels, parallel bars, hook and clasp puzzles, shelves, revolving wheels, mesh-covered poles, and transportable rubber toys. Two, one-way observation windows allowed two experimenters to observe and record the responses of the monkeys.

Each of the subjects comprising the three primary experimental groups, i.e. 4-TT, 2-TT and SP subjects, was tested in groups of four monkeys from the same rearing condition, 20 min per day in playroom I, 5 days per week from 3 weeks until 6 months of age. The subjects were carried to the playroom either in pairs, SP and 2-TT groups, or in fours, 4-TT, in transport cages; while stressful for the first 3 to 4 weeks, this procedure was adapted to completely thereafter. Each of the two experimenters observed one subject at a time for twenty 30-s intervals using a modification of Rosenblum’s frequency system (Rosenblum 1961). In addition, the 4-TT subjects were quantitatively observed once daily, for 30 min, 5 days a week in their home cage, following the scoring procedures used in the playroom.

The MP comparison animals were raised and tested in standard playpen units, following procedures detailed by Hansen (1966), who measured daily the behavioural performance of the groups of two infants, using a sampling technique and behaviour categories similar to those described below except for the fact that the time base used was 15 s.

The behaviour categories analysed were as follows: (a) non-social categories, including disturbance, object exploration, and self-play, (b) simple social categories, including social explore, parallel individual play, imitative explore, social facilitate, non-specific contact or proximity, social approach, social withdraw, submit, and social cling, and (c) complex social behaviours including contact and non-contact play, hostile threats, and sexual behaviour. Occurrence of any of these behaviours in the 30-s interval was noted for the subject being observed. Detailed descriptions and illustrations of these behaviours may be found in Rosenblum (1961).

Upon completion of the playroom testing, i.e. at 6 months of age, all four of the 2-TT monkeys were placed in the playroom for 40 min a day for 10 days, and a record was made of the number of clinging responses that each monkey made per 15-s interval with each of the other monkeys. These 2-TT dyads were then recombined so that each monkey lived for 2 weeks with a new partner, i.e. a monkey from the other dyad. Following 2 weeks of cross-pairing all four monkeys were again tested together in the playroom for a 2-week period during which time they continued to live with their new partner. They were subsequently housed individually for 2 weeks, after which a third session of playroom testing was conducted. During this final testing it was possible for each monkey to cling to his original partner, his second partner, or to an unfamiliar partner with whom he had enjoyed no paired living experience.

The two females of the special 2-TT group were paired starting at 1 month and were tested in an open field at age 60 and 120 days and in the Butler visual exploration box at age 80 and
140 days. They received no other tests or experience. The apparatus is described and detailed results are reported in Harlow (1969).

**Adult Testing**

When subjects of the 4-TT group were 1 to 1½ years of age they were briefly tested twice in a dual-cage enclosure as part of their rearing group of four and twice as part of a mixed group of four comprised of another subject reared only on a surrogate, a subject reared by a 'motherless mother', and a subject reared by a feral mother (see Alexander & Harlow 1965).

Three years after reaching sexual maturity, and after 5 years of individual housing, the nine female TT subjects, the four female SP, and six of the female MP subjects were tested in breeding cages using a procedure described by Harlow et al. (1966) which involved four pairings during the period of maximum turgescence of their perineum spaced over a period of 1 year with experienced, adroit feral males. Monkeys were rated for adequacy of sex behaviour by experienced, adroit experimenters. Those females which became pregnant were allowed to deliver their infants normally and their maternal behaviour was rated according to Arling & Harlow (1967). Animals not impregnated were later artificially inseminated and their maternal behaviour similarly tested.

The twenty-one female monkeys were then tested as described by Mitchell et al. (1966) singly once a week for five consecutive weeks in playroom III. Animals were tested for 15-min sessions under each one of the following test conditions presented in this order; week 1, no animal, week 2, a 1-month-old infant, week 3, a 6-month juvenile male, week 4, a 5-year-old feral male, and week 5, the subject's rearing partner.

Each of these test conditions was separated by a 7-day interval. The durations of the previously indicated behaviours were recorded by one experimenter in the first four tests and by two in the final test. Table I summarizes living and testing history.

**Statistical Analysis**

Statistical judgements about group differences in the infant-testing situation were based upon the confidence interval procedure as recommended by Snedecor & Cochran (1967). The intervals were a pooled estimate based upon modified frequency data collected from the two SP groups. To plot MP data on a comparable scale in the figures, their values were converted to modified frequency/unit time scored. The 5 per cent confidence level was adopted throughout. The durations scores provided by the adult dual cage and playroom testing were assessed by means of repeated measures analyses of variance. Here MP data were included in the analyses. All differences reported are significant unless specifically stated otherwise.

**Table I. Living and Testing History of Monkeys.**

<table>
<thead>
<tr>
<th>Age</th>
<th>2-TT</th>
<th>4-TT</th>
<th>SP</th>
<th>MP</th>
<th>Special 2-TT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-12 months</td>
<td>Pairs 4F</td>
<td>Quadrads 1M, 3F</td>
<td>Alone with surrogate 4M, 4F</td>
<td>Alone with mother 10M, 10F</td>
<td>Pairs starting at 1 month of age, 2F</td>
</tr>
<tr>
<td>12 months</td>
<td>Recombination 4F</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1-6 years</td>
<td>Alone</td>
<td>Alone</td>
<td>Alone</td>
<td>Alone</td>
<td>Alone</td>
</tr>
<tr>
<td>Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-6 months</td>
<td>Playroom quadrads 4F</td>
<td>Playroom quadrads 1M, 3F</td>
<td>Playroom quadrads surrogate, 4M, 4F</td>
<td>Playpen, pairs with mother 10M, 10F</td>
<td>See text 2F</td>
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<tr>
<td>12 months</td>
<td>Playroom quadrads 4F</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>18 months</td>
<td>None</td>
<td>Dual cage 1M, 3F</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>6 years</td>
<td>Adult test 4F</td>
<td>Adult test 3F Adult test 4F</td>
<td>Adult test 4F</td>
<td>Adult test 2F</td>
<td></td>
</tr>
</tbody>
</table>

*The numeral refers to the number and the letter to the sex of those used.*
Fig. 2. Four 4-TT monkeys, two engaged in dorso-ventral and two in ventro-ventral cling. This illustrates the tenacity of the cling response even when one infant is separated by mesh. The trauma of forced separation plus photography evokes the TT cling pattern seen in response to a fearful situation.

Chamove et al., *Anim. Behav.*, 21, 2
Infant Testing

One striking finding of the present investigation was the high frequency and persistence of social clinging by the 2-TT monkeys. This behaviour pattern became significantly more frequent in the 2-TT subjects than in the other subjects by 60 days of age, and this difference was maintained subsequently as illustrated in Fig. 1. There was considerable similarity between the four groups in frequency of social clinging responses during the first 30 days whether made to the real mother, surrogate mother, or peer-partner, although the direction of response was clearly different. However, the MP group clung more than other groups during the first month, as Hinde & Atkinson would predict (1970), more than SP subjects the second month and less than SP subjects after 3 months of age. The importance of clinging was indicated by the fact that 40 per cent of all infant behaviours scored fell within the social clinging category during the first 30-day period. In the home cage, the 4-TT's social clinging was half as frequent as in the playroom and showed a parallel decline over time in that group of monkeys.

Results

During the subsequent 30-day test period two diametrically opposite trends developed. The 2-TT subjects showed an increase in the frequency of social clinging almost mirrored by a reduction in clinging of the other monkey groups. Thus, when the 2-TT subjects were 6 months of age 80 per cent of their playroom behaviour was clinging behaviour while only 5 to 10 per cent of behaviour was clinging in the other groups. The clinging behaviour of the 4-TT subjects in their home cage paralleled their decrease of clinging observed in the playroom but at a lower absolute frequency than in the playroom (Harlow 1959). On the other hand, qualitative observations indicated that the high level of playroom clinging was also in evidence in the home cage in the 2-TT group.

The form of this infant-infant clinging behaviour was primarily expressed in two basic patterns: one dorso-ventral, where one infant clasped tightly to the back of the other, and another ventro-ventral, where the ventral surface of both subjects were in contact. Both are illustrated in Plate VI, Fig. 2. The ventro-ventral clinging by the 2-TT subjects was quite prevalent during the first test months, but subsequently decreased and became less common than dorso-ventral. It is noted that dorso-ventral clinging within each 2-TT dyad tended to be unidirectional, with one member of the pair consistently clinging to the dark of the other and not the reverse. This dorso-ventral clinging pattern often resulted in the non-clinging partner literally carrying the other around the room during the former's exploratory excursions. Similar dorso-ventral clinging (see Plate VI, Fig. 2) was also observed in the 4-TT group.

The developmental trend for both contact and non-contact play by the groups of monkeys in the four rearing conditions presented a picture different from that of social clinging. As illustrated by the contact play data given in Fig. 3 all four groups started at a similar level and rapidly diverged. The MP monkeys played significantly less than SP monkeys during the first 2 months but played more than SP animals by 150 days. By 3 months both groups of TT monkeys played significantly less than MP and SP monkeys. However, the quality of play, when occurring, appeared similar to that in the other groups. It was rarely seen in 4-TTs in the home cage. It should be noted that 4-TT animals lived with all animals with which they were tested, 2-TTs lived with one, SPs lived with none, and MPs had their mother present nearby. Despite this familiarity effect,
Infantile socially directed sexual behaviour. Frequency was non-existent in the 2-TT subjects in keeping with the fact that ventro-ventral clinging precludes normal sexual posturing (although not thrusting of course) in macaques. The frequency and form of sex in both the male and female 4-TT subjects were comparable to that in the SP group, although considerably lower in frequency, and at 4 months significantly lower in frequency than in MP monkeys (see Harlow 1969).

However, the frequency of infantile sex by 4-TT subjects in the home cage was found to be similar to that of MP animals in reaching an asymptotic value of 0·8 by day 120. From other
work it was not felt that the absence of males in the 2-TT group influenced to any extent the sexual abnormality found in this group.

The infrequent occurrence of disturbance, such as the commonly observed patterns of vocalization or stereotyped movements, illustrated the apparent efficiency of the together-together situation. Home cage disturbance in 4-TT monkeys, except during the first 30-day block when it was three times greater, was as low or lower than in the playroom. Similarly, observations of the special 2-TT group in the open-field situation revealed a relative absence of the commonly observed disturbance patterns. However, interpretation of disturbance behaviour in these variously reared subjects involves a consideration of the treatment of the cling patterns. It is clear from Fig. 6 that if clinging is excluded from a consideration of disturbance, the TT situations are quite effective in ameliorating infant anxiety under test conditions. If, however, one considers the cling pattern itself as a manifestation of disturbance (Harlow 1969) then, as reflected in comparison of Figs 1 and 6, it is evident that the 2-TT situation was the least efficient in reducing situational anxiety or disturbance.

The question now arises: what did the 4-TT subjects do? To answer this we must turn to categories of behaviour described as non-social and simple social. In the former we find self-play greater again by half in the 4-TT subjects in the playroom than in any of the other groups. In the latter category by day 180, behaviours such as social facilitation (one subject repeating another subject's behaviour) were four times greater. Parallel exploration (a simple social behaviour) ten times greater, and non-specific contact four times greater than in the other groups. Social exploration was ten times less frequent than in other groups, but the percentage of this behaviour which was oral, as compared to visual or manual, was far greater in the 4-TT subjects than other subjects, oral behaviour being indicative of mild disturbance. Patterns of social response or qualitative differences also distinguished this group from others. Social approach was equal in frequency to social withdrawal and appeared at about half the frequency as in the other groups, in which approach was more frequent than withdrawal.

Affiliative behaviours, such as social cling, play, and social approach, showed the same interaction structure for both 4-TT and SP groups. In these behaviours there was an increase in the frequency of initiating affiliative behaviours with a decrease in subjectively assessed dominance rank and an increase in the receipt of affiliative behaviours with an increase in dominance rank.

The results of the recombination pairing of the 2-TT subjects are illustrated in Fig. 7. As would be expected, the original peer partners preferred to cling exclusively to one another during the first sessions, supporting the results of Butler box and open-field testing reported in Harlow (1969). To our surprise after the subjects were cross-paired in their home cages the monkeys immediately moved into intense and prolonged ventro-ventral cling with the new partner. When all four subjects were tested in the playroom 2 weeks after the initiation of recombination, clinging was then directed only towards the new partner. The clinging re-arrangement was certainly no mere undirected dissolution of the original fixation for the original peer partner, for neither the old partners nor the unfamiliar partner received any attention whatsoever. The results obtained during the third playroom period, following 2 weeks of individual housing, were equally surprising. A clear-cut preference for the
original partner was evident again, even though the members of this pair had neither lived together nor experienced clinging contact with one another for 6 weeks.

**Adult Testing**

The results of testing 4-TT monkeys at 1 to 1½ years supported earlier findings. The 4-TT animals remained significantly below both mother-reared groups in contact play and sexual initiation when tested both within their rearing group and among the strangers. The 4-TT subjects when tested at 1 to 1½ years in their own group, showed consistently more hostile behaviour than that exhibited by subjects from the other three groups (see Alexander & Harlow 1965 for details).

Testing for sexual adequacy at 6 years clearly demonstrated that the 4-TTs were as adequate as any laboratory reared animals but that the six 2-TTs were inadequate. The experimenters characterized all six 2-TT females as having a lack of enthusiasm for sexual contacts, showing inadequate support patterns when mounted, and being low in affection for the male. Only one 2-TT (a special 2-TT) allowed insemination, and that subject’s pattern was characterized as being one of passive acceptance. In contrast, all three 4-TT females positioned themselves effectively, appeared motivated toward social interaction, and co-operated with enthusiasm.

The results from testing maternal behaviour of the TT females are at present equivocal.

Three 2-TTs, two of which were forcibly inseminated, and two 4-TTs have had infants. Two of the 2-TT mothers were rated as adequate and one as indifferent. One of the 4-TT mothers was rated abusive and the other as adequate.

Regarding the assessment of general social adequacy of the subjects of each treatment group, the 9-year lapse since previous social experience appeared to have reduced social behaviour in all groups to such a low level that differences were difficult to detect using the normally sensitive stimulus-animal situation. The most significant difference was the greater number of low proximity scores and active orientation toward the infant by members of both types of together-together groups.

Two-thirds of these behaviours were non-contact in nature in both groups of TT animals whereas in the SP and MP groups, contact with the infant was three times greater than non-contact. Unlike the other groups, the TT animals responded significantly more to the various social stimuli in terms of dominance-subordinative relationships. Thus all TT subjects alone manifested dominance routinely and more frequently threatened the infant. Furthermore, the 2-TTs showed more threats to juveniles and adults and more submits toward the infant and rearing partner than members of any other group. It should be noted that infant-directed aggression is abnormal and adult-directed aggression is both abnormal and suicidal in the laboratory situation since it leads to hostile responses by the adult. In the 2-TT monkeys the frequency of adult-directed hostility was abnormally high when compared to the other groups even when leading to swift retaliation by the adult, and normal submissive patterns were less frequently employed by members of this group.

Differences between MP and SP subjects were consistently in favour of MP subjects, showing relatively more normal responding by the MP subjects. The SP animals tended to show higher disturbance and fewer responding in all situations and more withdrawal in the adult stimulus situation than MP subjects.

**Discussion**

The present experiment traced the development of responsiveness of monkey infants to maternal figures or maternal substitutes and observed the effects of those maternal variables on social development. Two of the experimental groups endured total maternal deprivation. The only
maternal substitute available to one of these groups was a single peer and to the other, three peers. Of the remaining two groups, one was raised with real mothers and the other with a cloth surrogate.

It has already been demonstrated that the primary variable binding the infant to its mother is physical contact, although other variables (see also Hinde & Atkinson 1970) of obvious importance include nursing, warmth, and the proprioceptive stimulation of rocking (Harlow & Harlow 1965). It is therefore not surprising that during the first month of life the highest frequency of clinging was found in the mother-raised subjects because of the presence of all these variables. The first abnormality requiring explanation is the precipitous rise and subsequent maintenance of abnormal levels of clinging in 2-TT infants. An infant raised on a cloth surrogate is free to leave at will, and this doubtless accounted for the early reduction in frequency of clinging responses in subjects raised in this manner, whose progressively increased separation from the surrogate reflects increased mobility, curiosity, and probably security as the affectional bonds increased towards the surrogate.

Decreasing clinging in infants toward their real mother was influenced by all of the above factors and also by the fact that many real mothers began at about 90 days to show, with increasing frequency, non-abusive but forceful infant rejection. It appeared that without early restraint, as seen in Bonnet macaques (Rosenblum & Kaufman 1968), mothers of 'twins' (Deets 1969), and surrogates, this maternal rejection was not necessary for the development of infant independence. But in rhesus with normally early-protective mothers, the onset of ambivalence in a given mother was closely related with independence, e.g. exploration and play, in the infants.

The progressive decrease in clinging in the 4-TT presented a new paradox. They did not show excessive clinging as did 2-TT babies, and yet did show subsequent social impairment. The only way in which their clinging differed from that of the 2-TT subjects, aside from frequency, was in the shifting of clinging patterns and the breaking of old patterns. For example, every subject showed at least one change in clinging preference during the 6 months of testing, three of these subjects showing changes after the second month. This increase in the number of affectional objects may have diluted affection; it may also have ameliorated the development of adverse social behaviours. The clinging patterns of the 2-TT can be viewed as being both specific and mutually interfering, specific in being directed toward only one maternal figure, and mutually interfering in that when one partner attempted to disengage from the mutual clinging, the other often would inhibit this escape by more vigorous clinging. It also must be noted that clinging is not solely beneficial affection and productive of normal development, for just as MP clinging behaviour led to normal development, 2-TT clinging did not, and the switching pairs of 2-TT subjects further demonstrated this fact.

It is an intriguing and important hypothesis that the contact-clinging response, which is a primary variable influencing infant-mother affection, is an inhibiting variable in subsequent age-mate affectional systems. It is obvious that the variables which underlie one affectional system do not necessarily underlie another. The demonstration that there can be variables which inhibit one and facilitate another would be a more striking finding, but the behaviour of 4-TT subjects did not support this.

As we have already shown (Harlow & Harlow 1965), the peer affectional system is coterminous and probably dependent upon various forms of play. The infants of mothers and surrogates showed a relatively normal developmental play course, and differences express the fact that the surrogate's role was entirely passive. The surrogates did not restrain the infant early in life nor abet the normal separation process later. In sharp contrast was the lack of play in TT infants. This was supported by the deficiency in threat responses, social signs which are important in the development of play and social ordering. In a sense they were like children in an orphanage where playmates are plentiful but mothering is inevitably inadequate.

The abnormal rearing conditions of the 2-TT subjects, and to a lesser extent the 4-TT animals, impaired the development of general social behaviour in these groups. The abnormal development of assertive behaviours as described above, during infancy, when juveniles, and when mature, were results of the abnormal development of attachment and independence processes. Although the physical attachment behaviour of TT and mother-raised monkeys appeared similar, the maternal-like attachment of an infant to another infant permanently inhibited rather than facilitated the development of peer-peer social interaction.
Acknowledgments
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Varying infant rhesus social housing*

A.S. Chamove

Many laboratories rear their own experimental animals and the conditions in which they are housed is partly determined by the immediate research requirements\(^2\),\(^3\). The most common housing situation for the new-born monkey is alone in a cage from birth or soon after\(^4\),\(^5\). Less likely, the neonate can be housed with its mother for a short period and subsequently alone\(^6\). And finally even more rarely the infant is paired from an early age with a peer, i.e., animal of similar age.

The present study, originally designed to investigate the excessive clinging and deficiency of play in pair-reared monkeys, evaluates and compares various modifications of peer housing. It demonstrates that providing young monkeys with a variety of playmates produces animals which are able to integrate into larger groups better than monkeys given less or no opportunity for companionship during early life.

**Method**

**Subjects**

Twenty-eight infant *Macaca mulatta* and two *Macaca nemestrina-mulatta* crossbreeds were separated from their mothers soon after birth and maintained individually in single wire mesh cages until the start of the experiment\(^5\). They were given a diaper for the first month and could see and hear other monkeys. Most of the animals were females but each group contained at least one or two males.

**Apparatus**

During the first year of life individual animals and pairs of animals were housed in cages measuring 460X 610X 610mm and the large groups were housed in units of 690X 740X 122mm dimensions. When the monkeys were one year old the cage area was increased to 460X 610X 1220 and 690X 740X 244mm respectively. Cages were of 10mm stainless steel mesh.

*This paper briefly summarises a small part of the results of an MA thesis which should be consulted for detail\(^1\) and it is available upon request from the author.*
The major evaluative sessions with stimulus animals were conducted in a 5.9m² playroom constructed of white fibreglass, with a two-way window in one side. It was 2,100mm high and had two mesh platforms 1.1m² in area.

Evaluations in groups of six utilised a 4.1m² hexagonal room with 2.6m² wooden mesh platforms. Walls were yellow, the wooden shelf red, and floor grey. It too was 2.1m high with a two-way observation window. A checklist was used to record behaviours.

Procedure

Housing. The thirty rhesus monkeys were divided into five groups of six. In each of these groups two animals started the experimental treatment after 12 weeks of age (mean 15), two when between 9 and 11 weeks of age (mean 10), and two when between 5 and 8 weeks (mean 6.5). The treatment lasted for twelve weeks.

Group 1: The Together-Together (T-T) group consisted of a total of six monkeys housed in three pairs. Each animal was always with the same housing partner.

Group 2: Six monkeys were termed the Together-Apart (T-A) group and were reared in unchanging pairs like the T-T animals except that on alternate weeks each of the six were housed individually in cages.

Group 3: The Changing-Together (C-T) group was composed of six infants reared in changing pairs and were never housed singly. Every week the pairing was changed so that animal A was paired with B for a week, C for a week, etc.

Group 4: This group was termed the Social-Group (S-G) and was composed of six infants housed continuously in an unchanging group of six, all in one large cage.

Group 5: The final group, the Social-Isolate group (S-I), was composed of a group of six monkeys reared individually.

In summary the animals of groups T-T, S-G, and C-T were continuously living with other animals; animals of groups T-T and T-A had living experience with only one partner throughout the experimental period; monkeys of groups C-T and S-G had experience with a total of five other animals, the S-G all at one time, the C-T over a five week period one at a time; the S-I infants lived alone.

Subjects were housed as described for the first basic twelve weeks of the experimental treatment which began when the infants were 10 weeks old on average. For the next eight weeks, when the infants were between 22 and 30 weeks of age, all the animals except the S-I were housed in pairs. Then for the next ten weeks and until the monkeys were 40 weeks old all were housed individually. Then for ten weeks all groups were returned to their normal experimental housing condition until the subjects were 50 weeks old. And for the final five weeks of the first-year evaluation period all infants were housed in a group of six with the other members of their group during the interval
when between 50 and 55 weeks of age. This housing following the basic twelve weeks was termed the supplementary housing period as it was designed to evaluate housing change subsequent to the basic housing design. During all this time the first period of testing (group testing) was carried out.

After termination of testing at one year of age all monkeys were housed alone for two weeks, in groups of six for ten weeks, alone for forty weeks to measure food intake, returned to their experimental treatment condition for four weeks prior to retesting, and then alone for one week and throughout the second period of testing. This second test period was designated the stimulus testing period.

**Testing.** Homecage testing was performed by briefly observing each animal five times daily for five seconds throughout the first forty-five weeks of the study. At the end of experimental weeks 10, 11, 12, 20, 30, 40, and 45 all six animals of a group were placed in the playroom together and observed for forty minutes, Playroom-group Testing.

When animals were approximately two years old they were tested in another playroom on six consecutive days for 15 minutes per day. On each of the first three days the subject was put in the playroom with one of the three stimulus animal types; and on the second three days the subject was put in with one of the three stimulus animals plus the cage-mate from its group with which it was most familiar so as to increase the self-confidence of the test subject. On the first and fourth days the stimulus animal was a one month old infant, on the second and fifth days it was a year old juvenile, and on the third and sixth test days, it was an adult male of four years.

Accumulated records of social and non-social behaviours were recorded on clocks, during Stimulus Animal Testing, one clock per recorded behaviour. The five behaviours utilized were as follows: *self-clinging*, subject clamping a part of its own body or hair with hand(s) or feet; *social clinging*, clinging to another animal, such as dorso-ventral or ventro-ventral cling; *self-play*, active unemotional, non-stereotyped, complex interaction with self or an inanimate part of the environment; *social play*, play with another animal; *aggression*, biting, slapping, threatening, chasing with threats, grabbing another monkey. During Playroom-group testing all six subjects were observed at once by one experimenter and the presence or absence of any of the five behaviours was dictated to a second experimenter. The test periods lasted 40 minutes and intervals of one minute were used so that a subject could receive a maximum score of 40 if a given behaviour was observed at least once in each of the 40 1-minute test intervals.

**Analysis** was by means of a series of unweighted means repeated measures analyses of variance. Differences occurring with a probability of less than .025 were accepted as statistically stable. This more conservative confidence level was selected because of doubt in the ability to meet the assumption of
homogeneity of variance. Subsequent tests on behavioural categories reaching statistical significance utilized the Kruskal-Wallis One-Way Analysis of Variance by Ranks test. All results reported here are significant unless specifically stated otherwise. As the behaviour of or towards the two crossbreeds did not appear to differ from that of the rhesus, their results are included with the others.

Results

Homecage testing

There were no between-group differences observed in the homecage until week forty-five, when four of the five groups (all except the S-G) were housed in sixes for the first time. The plan to maintain this condition for ten weeks had to be abandoned because of the severe aggression in three of the groups. Whereas the S-G and C-T animals adapted well to the new housing condition, the others did not. The animals of the last group to be tested, the S-I group, were not able to remain together for even five weeks. One animal had to be removed for three days to an oxygen-supplied isoclette. After almost constant harassment and attack by other(s) monkeys it was bruised and appeared exhausted. Breathing was shallow and appetite poor. Three of the others were separated for a period of twenty-four hours to ensure their survival. Aggression in the T-T and T-A monkeys was less intense but sufficient for group housing longer than five weeks to have been dangerous to the infant monkeys.

FIGURE 1 Members of the S-G illustrating the dorso-ventral cling pattern induced here by the mild threat of photography in the home cage
One interesting observation was the pattern of social clinging, utilized by the S-G. Whereas the normal mother-infant pattern in rhesus monkeys is ventro-ventral clinging, the pattern most commonly utilized between pairs of infants in T-T, C-T and even T-A groups in this study, the S-G monkeys adopted a dorso-ventral pattern as can be seen in figure 1. This enabled the infant rhesus to maintain contact and still locomote, albeit slowly, whereas the ventro-ventral cling of the T-T, for example, often rendered locomotion impossible. When sleeping or highly stressed, the six infants often modified their dorso-ventral pattern to a mixed one (see figure 2) of dorso-ventral and ventro-ventral.
Figure 3: The results of week forty-five (age 55 weeks) playroom-group testing subsequent to five weeks of group housing. The maximum score is 40

Playroom-group testing

The results of the evaluation undertaken after week forty-five appear in figure 3. The S-G animals, although spending considerable time clinging, are, along with the C-T, the least aggressive and most playful in groups. The S-I are clearly lowest in play and highest in aggression. The other two groups, those having had only one other social companion throughout the experimental period, are intermediate in play and aggression between the groups with five other social companions and the groups with none.

Figure 4 shows a modification of the scores, taken during Playroom-group tests between the ages of 20 and 55 weeks, into an ‘adjustment’ score. This consisted of twice the frequency of social play plus the frequency of self-play minus the frequency of clinging. This score is arbitrary but determined a priori. The rationale for weighing social play more than self-play was the importance of this measure in discussions of effects of isolation, separation, etc., by other primatologists.
Those animals having had experience with five others early in life score above those having had experience with one other, and the latter are in turn above the social isolate monkeys.

**Playroom-stimulus animal testing**

The evaluation performed when subjects were a year older and in a very different and more controlled social situation confirms and extends the findings reported above. The S-G and C-T monkeys show none of the abnormal aggression evinced in the other groups toward the fully mature and far larger stimulus adult (see figure 5). The bullying aggression toward the smaller juvenile seen in the T-T and S-I is further evidence of their abnormality. Overall the two five-partner groups were more playful, less clinging, and less aggressive than the other monkey groups. The S-I exhibited most persistent clinging of all.

![Graph](image_url)

**Figure 4** Playroom-group test results throughout the year-one evaluative period. 
*Adjustment = (2 * X social play) − (clinging) ÷ (self-play)*
Age interactions

The main consequence of starting social experience when older than three months of age was the better adjustment of these older animals. We arbitrarily divided the age categories into above three months versus below that age, i.e., the older two versus the younger four group members. This was done because in the former self-cling patterns had been developed and were maintained, whereas in those paired or grouped before age three months a social cling pattern was observed. It should be noted that this pattern was less evident in S-G animals than in the other groups. The overall amount of clinging was about equal in the two age groups although the form of its expression was clearly different. Play was in general more frequent in the older than in the younger animals, self-play more frequent in older multiple-partner groups and social play more in single-partner groups. Older monkeys were less aggressive in the two single-partner groups.

FIGURE 5  Playroom-stimulus test results summing over the three stimulus-animal types and the two familiar peer conditions (absent/present)
Discussion

It has been shown that animals can be reared in small cages so as to enable them to adjust to living with other animals at an older age. Those reared alone in cages adjust poorly to brief group testing with similarly-reared monkeys, more prolonged group housing, and to brief testing with older or younger stimulus animals. Infant rhesus reared in the company of the same (and only one) animal present, either continuously or on alternate weeks, are hyper-aggressive towards younger, like-aged, and older animals. Animals either paired with five other animals or in groups of six appear to develop so as to be adaptable to other types of social situations.

The age when starting the socialisation has a small but measurable effect, appearing to be better when started soon after that magical age of three months. This is the critical age for the development of social clinging in the rhesus, if it has not developed, it tends not to; and this is the age at which social fear first appears.

The optimal conditions of rearing in order to achieve economy of caging, high levels of play, and low levels of both clinging and aggression is seen to be the C-T. Here animals were housed in pairs the members of which were switched at weekly intervals so that for each of five weeks, each of the infants was paired with a different peer, after which the cycle was begun again.

When directly compared with another group of animals reared both by mothers and with peers in the laboratory, these C-T monkeys were more playful toward the monkeys and less aggressive toward humans than the mother-peer raised animals. These Changing-Together monkeys were so playful and unaggressive, yet assertive enough when need be, that they were chosen to be used as ‘therapists’ in the rehabilitation of some isolate monkeys.

Animals from all groups except the isolates were seen to adopt normal sexual posturing, and it was felt that when mature their skills were adequate for successful copulation.

Speculation

It is interesting to compare the group-test and stimulus-test data of the above thirty macaques with other date collected by the author in similar situations from animals reared in different conditions7. These can only be suggestive as items such as minutes of peer contact per day, playroom experience, and duration of experimental treatment are not identical.

The rearing situations are as follows: Surrogate-peer, reared with a terry-cloth-covered sandbag or mesh cylinder and tested daily in a playroom in groups of four, with the surrogate present, for about 30 minutes per day; Mother-only, reared with a mother and no other peer or monkey contact (unpublished data); Mother-peer, reared with a mother and given daily peer opportunity for 30 minutes; Peer-pairs, raised in individual cages but given
daily peer contact for about an hour in the homecage in pairs with a total of three other monkeys, the pair members changing every day; and finally Peer-groups, raised in individual cages but given about 30 minutes per day in a playroom or large pen in a group of four age-mates.

In general one can conclude that whereas increasing variety in peer rearing leads to reduced aggression and increased adaptability and mother rearing leads to increased assertiveness, the combination of mother and peer rearing produces even greater assertiveness and yet not to the extent of hyperaggressiveness. All of these groups were socially adequate and better than the S-I, T-T, and T-A groups described above. Modifications of group membership were easy in all but the two mothered groups (personal observations).

The mother-peer groups were very assertive animals. In comparison the mother-only group showed less dominance, less submissive behaviour, and less play. The surrogate-peer group exhibited 60% of the contact play, half the social threats and immature sexual behaviour as the mother-peer group. Whereas another group of four Together-Together showed only one-third the contact play, hardly any of the social threat, and no sexual behaviour compared with the mother-peer animals. The two peer-only groups did not differ from one another. They were relatively non-aggressive and playful when compared with all but the surrogate-peer monkeys. They were so adaptable that the peer-pair procedure was adopted as the standard procedure for the medical section of the Wisconsin Primate Research Center3. This procedure enabled control and measurement of individual dietary intake and yet enabled housing in groups once this measurement was discontinued. It also enabled testing for social adequacy after termination of abnormal diets8. And, in case of death, it enabled relatively simple changes in group composition in order to maximally utilise group caging facilities.

Summary and conclusions
A socially adequate rhesus monkey can be produced from housing with relatively restricted social opportunity. Social experience with more than one other peer, or age-mate, from around the age of three months either (a) housed continuously in a group, (b) housed continuously in pairs which change weekly, (c) given 30 minutes of social experience/day in a group, or (d) given a few hours of social experience in changing pairs in a rather small cage – either of these (or perhaps even better some combination) results in animals having a level of social facility desirable in subsequently individual- or group-housed macaques.

Acknowledgements
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where this study was conducted. Assistance from Mr John Wolf in data tabulation, Mrs J. Beattie in manuscript preparation and guidance from Dr H.F. Harlow is gratefully acknowledged.

References


REARING INFANT Rhesus TOGETHER

by

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(University of Wisconsin Primate Laboratory, Madison, Wisconsin, U.S.A.)

(With 6 Figures)

(Rec. 30-IX-1972)

Experimental studies of the social development of monkeys (Harlow & Harlow, 1962) have shown that if the infants are not allowed to interact with one or more other monkeys in early life they tend to develop excessive social fear and/or hyperaggression, traits which interfere with the development of normal social interactive patterns and subsequent reproductive behaviour. However, Chamove et al. (in press) have demonstrated that allowing two newborn infants to continuously interact with only each other produces socially abnormal monkeys that develop what has been called the together-together syndrome. This syndrome is characterized by an excessive amount of socially directed clinging behaviour and greatly reduced social play during the first 15 months of life. On the other hand infants reared only with their mother for 8 months do not show this syndrome. This has been explained with recourse to the tendency of a mother to begin to reject the clinging attention of the infant with increasing frequency starting at about three months of age.

A human study with pertinent homologies to the monkey together-together conditions was conducted by Freud & Dann (1951). Four infants who lost their mothers at birth and two additional infants who were under a year of age when separated from their mothers, were reared as a group in Tereszin concentration camp for over 2 years with an absolute minimum of extra-group contact. After prolonged observation and study of these children, the authors reported the following: the children’s positive feelings

1) The author wishes to thank Mrs T. Friedman, Drs J. A. Bauer Jr., R. C. Wolf, C. I. Thompson, and H. F. Harlow for assistance in testing, overall organization, obtaining monkeys, manuscript preparation, and general encouragement. This research satisfied part of the requirement of an M.A. at the University of Wisconsin, Madison. This research was supported by United States Public Health Service Grant MH-11894 from the National Institutes of Health to the University of Wisconsin Department of Psychology Primate Laboratory.

2) The current address of the author is Stirling University Psychology Primate Unit, Stirling, Scotland FK9 4LA.
were centred exclusively in their own group; they had no other wish than to be together and became upset when separated even for moments, (p. 131); toward the staff they behaved with either cold indifference or hostility (p. 160), standing up for one another whenever they felt a member of the group was threatened by an outsider. The authors concluded that there was an almost complete absence of intragroup rivalry and competition (p. 134).

In monkeys that have developed the classical together-together syndrome three antecedent rearing conditions have been present:

(1) social experience has occurred with only one partner at a time.

(2) the partner has always been the same partner, and

(3) the animal has always throughout some period of months, been exposed to the partner.

In the present study these three conditions were systematically manipulated to isolate the variables producing the together-together syndrome. The classical together-together situation was replicated by rearing a group of monkeys which met all three conditions outlined above. Three other groups were formed in which only two of these three conditions were present. A fifth group met none of the three conditions.

**METHODS**

Subjects.

Twenty-eight infant *Macaca mulatta* and two *Macaca nemestrina-mulatta* crossbreeds from the breeding colony of the University of Wisconsin Primate Laboratory were separated from their mothers 6-12 hours after birth and were maintained until the beginning of the experiment under the standard laboratory conditions of partial social isolation (Blomquist & Harlow, 1961). These animals were supplied with a diaper for the first month of life and housed in individual wire infant cages where they could see and hear but could not contact other monkeys.

In addition, 14 stimulus monkeys consisting of 10 infants under 1 month of age at time of testing, 2 juvenile females between the ages of 9 months and 1 year, and a pair of 4-year-old adult males were used in this investigation. Juveniles and adults were chosen for their tendency to initiate play with strange monkeys as judged by an independent, experienced investigator.

Apparatus.

*Living Chambers.* The cages used for housing the monkey subjects were of four types: infant cages measuring \(0.46 \times 0.61 \times 0.61\) m, used to house one subject or two subjects during the first year of life; large adult cages measuring \(0.60 \times 0.74 \times 1.2\) m, used to house six subjects during the first year life; and cages of the above two types placed end to end with the backs removed and used to house two or six subjects after 1 year.

*Test Chambers.* Wisconsin Playroom II described by Harlow, Rowland & Griffin (1964) was used for behavioural testing during the first year of life. This irregular hexagonal room was 2.1 m in height and had a floor area of 4.1 m². An enclosed plywood shelf and floor mesh platforms added 1.2 and 1.4 m², respectively, to the level.
area of the room. The experimenters sat outside the test chamber and observed the subjects through a two-way window during test sessions that were divided into periods regulated by a synchronous-motor microswitch apparatus. A check sheet was used to record behaviours which occurred during each observational period.

Wisconsin Playroom III, described by Mitchell (1968) was a square enclosure 2.1 m high with two mesh platforms adding 1.3 m² of level area to the 6 m² floor. Subjects were observed through a 1.3 × 2.1 m two-way window. Absolute durations of various behavioural categories were recorded using two banks of eight relay-operated Standard Electric Timers, one bank for each subject. These timers, activated by the depression of individual microswitches, were used both in Playroom III and for dominance testing.

Procedure.

Experimental Rearing Conditions. When the mean age of a set of six subjects reached 10.5 weeks (range: 5 to 16 weeks) these animals were assigned to one of the five experimental treatments so that two subjects from each group were between 5 and 7, two between 9 and 11, and two between 13 and 16 weeks of age. The first week of this treatment was designated as experimental Week 1. Most monkeys were female but all groups had either one or two males in it.

In the Changing-Together (Ch-To) group, six subjects were paired for one week in three infant cages. At the end of every week the pairing was changed randomly with two restrictions:

(a) that the cycle of pairings be completed before a pairing be repeated; and
(b) that on Weeks 12 and 40 the pairs consist of the two oldest, two middle, and two youngest animals ('age-mate pairs').

The Social-Grouped (So-Gr) monkeys were housed continuously in a large adult cage as a single group. In the Together-Together (To-To) group the two oldest, two middle, and two youngest animals were paired. These infants were continuously housed as 'age-mate pairs', each pair in one infant cage. The Together-Apart (To-Ap) animals were like the To-To group in rearing except that on alternate weeks all six monkeys lived alone in separate infant cages. The six subjects in the Social-Isolate (So-Is) group were reared alone in infant cages so that they could hear and see but not contact other monkeys. This group, and only this group, had no playroom experience until experimental Week 10 and was given no subsequent treatment until experimental Week 40.

Table I briefly summarizes the experimental rearing treatments. The variables are those referred to at the end of the Introduction section. The groups differed in terms of the number of partners ranging from zero to five and also in terms of the social interaction they had with the partner, if any. The three conditions of social interaction were whether there was one and only one partner at a time, whether or not the partner(s) remained the same, and whether the subjects were continuously with the partner(s). It will be noted that group So-Is met none and group To-To met all of the social criteria and that the other three groups met two of these criteria but never the same two.

Subsequent Housing Condition. After experimental Week 12, the four groups raised with partners were consecutively housed for seven weeks in the To-To situation, for ten weeks in the So-Is situation, and for ten weeks returned to their original rearing condition. During the next five weeks, i.e. through experimental Week 45, all five groups were housed in the So-Gr situation. All subjects were then consecutively housed as follows: — alone for four weeks, in groups of six for five weeks for dominance testing, and then alone for forty weeks. At this time the monkeys were returned to their original rearing condition for one month. Subsequently, all subjects were housed individually for one week at which time testing with stimulus animals was begun.
TABLE 1

Rearing conditions of five groups of six infant rhesus

Together-together variables

<table>
<thead>
<tr>
<th>With only one partner at a time</th>
<th>Unchanging partner(s)</th>
<th>Always with partner(s)</th>
<th>Total number of partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>So-Is</td>
<td>—</td>
<td>—</td>
<td>0</td>
</tr>
<tr>
<td>To-To</td>
<td>Yes</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>To-Ap</td>
<td>Yes</td>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>Ch-To</td>
<td>Yes</td>
<td>Yes</td>
<td>5</td>
</tr>
<tr>
<td>So-Gr</td>
<td>No</td>
<td>Yes</td>
<td>5</td>
</tr>
</tbody>
</table>

Test conditions.

Homecage testing was started for all subjects the week before initiation of the experimental treatment (Week O) and continued for 46 weeks. This was done by observing each animal four times a day for four 5-sec periods and noting the occurrence and direction of prescribed behaviours on a checklist. Animals were observed randomly with the restriction that one of these observations fall in the morning, two fall in the afternoon, and one fall in the evening.

Playroom-pair testing was initiated at the end of experimental Week 1, and groups were tested weekly for nine weeks. Subjects, except those in group So-Is, were put into Wisconsin Playroom II as pairs for one 45-minute session at the end of each experimental week. The To-To, To-Ap and So-Gr pairs were age-mate pairs and the Ch-To animals were placed in the playroom with the living partner from the previous week. At the end of experimental Week 9 playroom-pair testing was terminated, and playroom-group testing was begun at the end of experimental Week 10.

Playroom-group testing occurred at the end of experimental Weeks 10, 11, 12, 20, 30, 40, and 45, during which all six animals of each group were put into Playroom II and tested as a group for 40 minutes. Two experimenters were used. One watched the animals, and the second recorded the behaviours on a checklist as dictated by the first experimenter. All six animals were scored simultaneously in terms of the presence or absence of specific behaviours occurring during each of 40 1-minute observation periods. The score resulting was called the modified frequency. For social categories the direction of the behaviour was noted but tabulated only as once/1-minute period.

Dominance testing occurred at the end of experimental Weeks 45, 52, and 54. Each group of 6 was tested in its large adult homecage in a water competition situation (Alexander, 1966). The animals were deprived of water for 24 hours, given one water bottle for 30 minutes, deprived for 24 hours and again given one bottle. The test took place at the end of the second 24 hour period. The amount of time elapsed before a given subject drank from the bottle for 30 seconds was recorded for every monkey and the time for 60 seconds also.

Playroom stimulus-animal testing began when the animals were approximately 2 years old. They were tested in a strange playroom, Wisconsin Playroom III, with stimulus animals with which they were not familiar. During half of these sessions the subject's age-mate was absent, while throughout the second three days the age-mate was present. On the first and fourth days the stimulus animal was an infant. On the second and fifth days it was a juvenile, and on the third and sixth it was an adult. The stimulus animals during the second three days were different from those used during the first three days. The two juveniles and two adult stimulus animals were the same for all groups, but age disparity over groups necessitated using two different infants for each group.
All homecage, playroom-pair, playroom-group, and playroom stimulus-animal testing was conducted using five behavioural categories: (1) Self-cling; (2) Social clinging; (3) Self-play, scored when the subjects engaged in non-social play; (4) Social play, including approach-avoidance, rough and tumble, and contact play; and (5) Aggression, when the subjects made any socially directed attempt to dominate another animal. This included biting, threat, dominance mount, and 'object-steal'. For the social and aggression categories the animal toward which the behaviour was directed was recorded.

Analytical procedures.

The dependent variables used for major analysis were the above five behavioural categories. Using data from playroom-group testing, these categories were analysed for the effects of rearing, age of subject, and test weeks. Data from playroom stimulus-animal testing were analysed for rearing condition, peer presence, age of subject, and age of the stimulus animal. An analysis of variance, using the method of individual degrees of freedom recommended by Li (1964) was applied to the scores and F ratios occurring with a probability of less than .05 were accepted as statistically stable. The individual degree of freedom comparisons were non-orthogonal which is permitted because of the a priori nature of the comparisons and consisted of comparisons between 'always' (To-To, Ch-To, and So-Gr) and 'non-always' (To-Ap) groups, between 'same' and 'non-same' (Ch-To) groups, between 'single' and 'non-single' (So-Gr) groups, and between zero, one, and five partner groups. It should be noted that the So-Is group was excluded from all analyses except the last. This was done because of the clear a priori nature of their differences. Subsequent Fisher's Least Significant Difference (L.S.D.) analyses were used when more detailed information was desired following a significant F.

A Chi-square One-Sample Test was employed to determine if subjects played with, clung to, or exhibited aggression against their age-mate or previous partner to a degree greater or less than toward other members of their social group. The dominance test was assessed by means of the Kolmogorov-Smirnov Two-Sample Test. All results presented below were significant beyond the .05 level as described above unless specifically stated otherwise.

RESULTS

The five groups of monkeys observed in the present investigation tended, in terms of accounting for the variance of the major social categories, to fall into three such categories: (a) the zero-partner group composed of the So-Is monkeys, (b) a one-partner category which included the To-Ap and To-To groups, and (c) a five-partner category composed of the So-Gr and the Ch-To animals. The So-Is or no-companion animals in general showed a lower score on most categories reflecting social adequacy or affiliation such as self-play and social play. The multiple or 5-partner groups were highest on all measures of play and low on aggressive behaviours. However, social clinging behaviour was greatest in the To-To and So-Gr, i.e. those subjects consistently housed with the same partners; whereas the members of the inconsistent partner group, the Ch-To, although always with another monkey exhibited little of this behaviour. This suggests that the together-together effect is due to being housed consistently with the same and only one other animal, and having no opportunity to develop affectional ties with any other monkeys.
**Homecage Testing.**

There were no between-group differences in total play (self- plus social) or total clinging during the first 41 weeks of homecage testing. This supports the idea that both of these behaviours have some fixed emission level, and this level or rate is relatively unaffected by the types of manipulations described herein. The type and direction of these are affected, but it is not in the adapted state and familiar homecage situation that experimental manipulations would be expected to have an effect.

In all five groups the total amount of clinging, which before Week 1 (10 weeks of age) was at 45 percent of the total intervals observed and after Week 1 at 25 percent reached a maximum between Weeks 3 and 7, when this behaviour was observed in about 55 percent of the observational periods. Clinging then declined to an asymptote of 10 percent between Weeks 15 and 25. Total play initially occurred during about 30 percent of the observational periods, dropping in frequency to 20 percent of the observational periods by Week 5 and then rising to an asymptote of 65 percent between Weeks 8 and 10 (our data plotted in Suomi, Harlow & Domek, 1970, pg. 171). Although the direction of homecage clinging and play was drastically altered as a function 'together' versus 'apart' housing, the overall frequency of play and clinging in the To-Ap animals followed the pattern of other social groups. Comparing the To-Ap monkeys' homecage frequency of behaviour when separated, with the previous paired week leads to the following figures. When apart the animals showed a reduction in clinging and an increase in play on 85 percent of such comparisons. There is little suggestion of anything which could be called a separation effect. The apart week after seven weeks of To-To housing showed an accentuated play increase, and one of the rare (self-) cling increases (Week 21).

Group differences in homecage testing appeared during experimental Weeks 41-45, the period during which all groups underwent social-group housing. For all but the So-Gr and Ch-To groups, this period was the first time that some of the monkeys had met in the homecage situation. In comparison with the results of the previous ten weeks, where all groups were housed in their original rearing conditions, a subsequent L.S.D. test showed a reduction in social play for all experimental groups except the subjects of the So-Gr, and a decrease in self-play and an increase in total clinging for all groups but the two five-partner groups (Ch-To and So-Gr). By the end of Week 45 aggression in the To-Ap and To-To groups was so severe that the lives of five animals were in danger, and therefore this housing condition was terminated. This housing condition also had to be terminated for the So-Is group at the same time, because aggression was even more severe in this group.
Playroom-pair Testing.

During Weeks 1-9 there were no differences between the four groups tested. The behaviour of each of these groups was characterized by an almost complete absence of any type of play, and a preponderance of social clinging and tentative environmental exploration.

Playroom-group and Playroom stimulus-animal Testing.

Cling. During the first three sessions of playroom-group testing, experimental Weeks 10, 11, and 12, there was a decrease in the number of 1-minute periods during which self-cling (see Figure 1) and social cling (see Figure 2) occurred evident only in the To-Ap group while the So-Is group increased their self-cling behaviour. As can be seen in Figure 1 summing over these three weeks there is a significant number-of-partner effect, the So-Gr subjects exhibiting the least and the So-Is subjects the most self-cling. Over the remainder of playroom-group testing there was a supporting tendency for the two 5-partner groups (Ch-To and So-Gr) to self-cling the least, the two 1-partner groups (To-To and To-Ap) to self-cling an intermediate amount, and the 0-partner group (So-Is) to self-cling the most. But this number of
partner effect only reaches statistical significance in the main effect when collapsed over all seven playroom-group tests. Subsequent housing conditions affected the frequency of this behaviour differentially in the five groups.

In the playroom-stimulus situation self-cling is very consistent across test conditions, and it clearly shows the significant 0-, 1-, and 5-partner differences described above (Figure 1).

Accounting for the most variance but not statistically stable, all but two (Weeks 30 and 45) of the seven playroom-group tests showed the three

![Fig. 2. Significant Group interactions in Social Cling.](image)

same-peer groups (So-Gr, To-Ap, and To-To) ranked higher in social cling behaviour than the other groups. Similarly, on all but two tests (Weeks 30 and 40) the always-same-peer groups (So-Gr and To-To) were ranked above the other groups. In the playroom-stimulus situation these tendencies were supported (Figure 2). These nonsignificant differences reach statistical significance in the comparison of the same-partner groups with the Ch-To group in the stressful adult-stimulus situation. Subsequent analysis revealed that the effect was due primarily to the So-Gr and To-Ap subjects but only in the adult-peer test situation. The three same-peer groups tended to be highest in the adult-peer stimulus situation whereas inspection of the data revealed the tendency for the two always-same-peer groups to be highest in the peer-stimulus situation with subadult stimulus animals.
A social-contact score was subsequently computed as it was believed that being the object of social cling might preclude the necessity for being the initiator of social cling. But social-contact results were almost identical to those of social cling.

**TABLE 2**

*Number of intervals in which cling was recorded in playroom-group test*

<table>
<thead>
<tr>
<th>Initiating Monkey</th>
<th>Recipient</th>
<th>Ch-To</th>
<th>Other</th>
<th>So-Gr</th>
<th>Self</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self</td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>6/12</td>
</tr>
<tr>
<td>1</td>
<td>2/4</td>
<td>3/8</td>
<td>9</td>
<td>2/83</td>
<td>6/53</td>
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<td>3/2</td>
<td>1</td>
<td>1/106</td>
<td>3/3</td>
<td>6/3</td>
</tr>
<tr>
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Animals are ordered in terms of age. First line reads — oldest animal of Ch-To group exhibited self-cling 4 times, cling to second oldest monkey 4 times, to third oldest monkey 8 times. The number of recipient columns is adjusted to reflect the great majority of cling responses, So-Is requiring none for social cling (only 8 responses were recorded) and the So-Gr requiring three columns.

**Play.** Over all seven of the playroom-group tests there was a non-significant tendency, which accounts for the greatest percentage of variance, for the two 5-partner groups to have the highest frequency and the o-partner group to have the lowest frequency of both social and self-play as is shown in Figures 3 and 4 respectively. The behaviours normally correlate about 0.60 with one another. Figure 4 represents the results on Week 45 showing the frequent play in the 5-partner monkeys. It may be of interest to note here that the homecage results for self-play show an almost identical pattern for Week 45, but the frequency is four times as great in the homecage.

In the less familiar and more rigorous playroom-stimulus situation these tendencies stabilize. The Ch-To and So-Gr were the only groups to show self-play behaviour when alone with any of the stimulus animals. Over the
Fig. 3. Significant Group interactions in Social Play

Fig. 4. Significant Group interactions in Self-play.
peer-stimulus conditions the significant separation into 0-, 1-, and 5-partner rearing was clearly seen in all three conditions. Social play in all three of the peer-stimulus situations showed the two 5-partner groups not differing and exhibiting longer durations of play behaviour than the other three groups, which did not differ significantly among themselves. For all groups the object of social play was almost exclusively the age-mate and not the stimulus animal regardless of age. But the ability to play at all in this situation is strong argument for the normalcy of 5-partner animals.

Aggression. During the first three weeks of playroom-group testing (age 22 weeks), aggression was found only in the three single-peer groups (Ch-To, To-Ap, and To-To) with an average frequency per test of almost two. Figure 5 illustrates the dramatic change and the highly significant number-of-partner effect following the social-group housing between Weeks 40 and 45. A similar partner-number effect, although not significant, was evident in stimulus-animal testing. It was as though the forced proximity of group housing and stimulus testing served to potentiate the aggressive responses not elicited in the large playroom during playroom-group testing and not elicited when housed with the rearing partner. To inhibit inappropriate aggression toward strangers, there appears to be a minimum number of attachment partners which need to be present during infancy.

![Diagram showing aggression rates across different conditions.](image)

Fig. 5. Significant Group interactions in Aggression behaviour.
Subsequent analysis of the significant partner-number effect in interaction with the peer-stimulus condition reveals that the effect was present only in the juvenile and adult stimuli situations; little aggression was shown toward the infant by any group. In both juvenile situations, the To-To group shows significantly more aggression than all but the So-Is group; the mean of the latter is half that of the former but not statistically significant. In the adult situation aggression shows a pattern similar to that shown when summing over the three peer-stimulus conditions (see Figure 5) except that To-Ap and To-To monkeys show almost all of their aggression when their peer is present, whereas the So-Is monkeys are not influenced by peer presence on this (or any other) measure. In fact the presence or absence of the familiar peer significantly interacts with the differential behaviour of all groups except So-Is for all behaviours measures, although often the relative ordering of groups is unaffected.

In the playroom-stimulus situation aggression was exhibited only towards the stimulus animal in all groups except the So-Is.

**Age effects.** Earlier social experience lead to less self-cling for the four groups in the first year of testing (as seen in Table 2). When paired or grouped the probability of shifting to a social type of clinging appeared to depend on the intensity of the self-cling response. When self-directed clinging responses were frequently observed before socialization, and this was more probable with increasing age, a social cling pattern was unlikely to subsequently develop. But in the So-Gr the two oldest animals, never strong self-clingers, in response to the clinging of those younger, gradually shifted to predominantly social clinging.

Early assembly was also related to less social play in To-To and To-Ap groups, and it was associated with less self-play in both Ch-To and So-Gr monkeys but more (not significantly) social play. In the playroom-stimulus situation early pairing was correlated with increased aggression in To-To and To-Ap animals.

It should be noted that age of first social experience is confounded with age at testing in all groups and with dominance rank in the 5-partner groups. The former effect is believed to be negligible. Nevertheless we feel that earlier grouping leads to a shift from self- to social cling and an improvement in hostile and playful responses in those groups with an adequate number of partners — five. In the 1-partner groups it was as though earlier pairing had the opposite effect, and late group assembly, contrawise, protected the infants for a longer period from the debilitating effects of To-To and To-Ap rearing.

**Other Measures.** A measure of social adjustment was computed: adjustment composed of the mean frequency of self-play plus twice social play
minus twice cling minus five times the frequency of aggression. The weightings were chosen as it was found in a previous study that infants tested in groups exhibit one-fifth the aggression, one-half the social play and half the amount of clinging as they exhibit self-play, the most prevalent behaviour. Adjustment showed no statistically stable differences in the homecage before week 45 or in playroom-pair testing although the younger To-To and To-Ap

Fig. 6. Adjustment score = (Self-play) + 2 (Social play) — 2 (Cling) — 5 (Aggression).

animals appeared slightly better than the older throughout most of the former. This fact is significant, indicating that the experimental subjects have adjusted to the social aspects of the homecage situation and can adjust within this social context to a change in environment as seen in the playroom-pair situation. These animals are not depressed, not hyperexcitable, not just barely alive. They are not like isolates.

In the playroom-group situation (as depicted graphically in Figure 6) however, the So-Is were lowest, the 1-partner groups were very similar to one another and the 5-partner groups were highest and again similar.

Subsequent housing had clear effects on the adjustment measure. The
To-To housing had no effect on To-To subjects, a slight beneficial effect on the two 5-partner groups, and a detrimental effect on the To-Ap group. This suggests that the weekly separations in To-Ap monkeys was a beneficial procedure. The subsequent isolation had a slight effect on the two 1-partner monkeys, but Ch-To animals showed a clear decrease, and So-Gr monkeys an even greater increase in adjustment after that condition. It was expected that some period of isolation would have a positive effect on all three groups composed of monkeys that were always with other animals. The lack of confirmation of this hypothesis in the To-To and Ch-To animals suggests that it is only in more stable (?) or secure group such as the So-Gr that isolation leads to a reduction of behaviour we classify as negative, e.g. cling, and increase in positive, such as play.

Group housing for five weeks resulted in somewhat better adjustment in Ch-To as expected, but a decrement in the other groups and a drastic decrease in adjustment in To-To subjects, cling increasing and play decreasing by a factor of two.

Age interacted with adjustment in most groups. The older subjects of all partner groups except Ch-To exhibited a lower initial adjustment score on weeks 10, 11, and 12. Thereafter the only major age effect was high relative adjustment score of the two oldest To-Ap subjects, at a level comparable to that of the older subjects of the 5-partner groups. Although the older two of the So-Gr, Ch-To, and To-To were slightly above the four younger animals of their groups on most weeks after Week 12, we feel that this nonsignificant tendency in the two 5-partner groups may have reflected the advantage of the older animals in a dominance hierarchy context.

A Social/Self-Directed ratio was computed for playroom-group testing. For the categories of play, groups showed a stepwise increase with the So-Is, To-Ap, To-To, So-Gr and Ch-To exhibiting 3.0, 21.8, 29.7, 37.5, and 42.6 percent social-directed play respectively. Cling was quite different. The So-Is subjects did not cling to other animals; the To-Ap and Ch-To were intermediate with 61.7 and 62.0 percent social-directed; and the So-Gr would cling 96.4 percent to other animals followed closely by To-To with 86.4 percent of their total clinging behaviour being socially directed. As predicted the changing of the pairs, both by separation (To-Ap) and by partner change (Ch-To), was effective in breaking up the social-cling pattern of peer-raised rhesus infants, the latter also leading to relatively normal social responding (Table 2).

Peer preference. In the playroom-group situation the social clinging results of the Chi-square test show that over Weeks 10-12, Weeks 20-40, and on Week 45 the To-To and To-Ap groups clung to their age-mate more than would be expected by chance in terms of total social opportunity. The Ch-To
animals showed statistically stable preferences for the partner of the previous week but only during the first three weeks of testing. Age-mate preference in So-Gr was only found over the first test block and is interpreted as a residual from playroom-pair testing; cling direction was not random in this group. This can be seen in Table 2.

Not surprisingly the two 1-partner groups show stable age-mate preferences throughout the first six test weeks in social play and the To-Ap group continued this pattern through Week 45. The preference for the partner of the previous week was found only during the first three weeks of testing in Ch-To animals as the direction of play.

This group tended to avoid directing aggression against age-mates throughout the first six test sessions but did not exhibit a similar avoidance of the previous week's partner. The So-Gr animals showed almost no selective direction for aggression; the To-Ap animals evinced some avoidance of age-mate aggression throughout testing, but it approaches significance only in the 20-40 Week block; the To-To rhesus exhibited some avoidance of age-mate-directed aggression from Weeks 20-45. The only block to contain sufficient scores for any Chi-square analysis in the So-Is group was Week 45 — aggression. It showed a strong tendency for avoidance of age-mate aggression, but this was the result of five subjects attacking one animal.

Dominance Testing.

There were no consistent differences between groups in dominance testing. The drinking time (until monkeys of a given rank drank for 30 or 60 seconds) was not consistently different between groups over the three test sessions. In addition there was no tendency in the To-To, To-Ap, or So-Is groups for the more active partner of Week 0 or Week 1 (frequency of play behaviour) to be the more dominant of the pair when tested in a group of six on week 45.

Subsequent Housing Conditions. The effects of subsequent pairing (To-To housing) during the interval between Weeks 12-20 on playroom behaviour were that of a reduction in social cling for the two 5-partner groups and a nonsignificant increase in the To-Ap monkeys. The pairing in the former was as a function on age, i.e. age-mate pairing, and took no account of the strong social cling-preferences already present. So especially in the So-Gr this split many of these 'natural pairs'. Surprisingly self-cling scores in the To-Ap group were not altered. Also unexpected was the absence of any reduction in self-cling behaviour after this change in housing. The To-Ap group showed less playroom social play after paired housing, but the greatest changes were again in the 5-partner groups. In these twelve animals there
was a reduction of the proportion of play which was socially directed. This was a result of a decrease in social play and perhaps also the result of an increase in aggression in the So-Gr, and as a result of an increase in self-play for the Ch-To subjects.

Ten weeks of individual or So-Is housing had the effect of decreasing the percent of clinging behaviour which was socially directed from 100 to 10 percent in the So-Gr subjects and from 75 to 59 percent in the To-To monkeys; a 10 percent drop in the Ch-To group was not a significant one. These changes were the consequence of a reduction in social clinging in the consistent So-Gr and To-To groups by a factor of seven and nine times respectively, while increasing this behaviour in the Ch-To animals. It was as though the former two groups ‘needed’ the separation whereas the less stable Ch-To found it disruptive. These weeks of isolate housing increased social but decreased self-play about 3.5 times in the So-Gr, but it decreased social play to about half that of the previous test in the To-To monkeys. Although the housing change had beneficial effects on the former, it had not in the latter (as it had had when evaluating clinging behaviour). The percent of play which was social in direction decreased from 25 to 17 percent in the To-To, whereas in the Ch-To there was a slight tendency to decrease their percentage. As social play is felt to be one of the most sensitive measures of social adjustment or adequacy in these rapidly developing monkeys, this decrease in social play in the To-To animals casts serious doubt on the advisability of individual housing for this group at this time.

Group housing increased playroom aggression in all groups except those consisting of 5-partners. In addition social clinging increased in To-To subjects. The To-Ap monkeys reduced both types of their clinging behaviour, primarily social, thus reducing their ratio of social to self-clinging from a very stable mean of just over 40 to under 20 percent. The Ch-To animals showed a reduction in aggressive behaviour and an increase in percent socially directed clinging showing that of their low amount of clinging behaviour over 90 percent is socially directed after this So-Gr housing condition.

DISCUSSION

The results obtained in this study are remarkably consistent over the 2-year period. Two factors can be used to account for the between-group differences in behaviours: (a) the number of partners, which correlates with aggression, play, and self-clinging, and (b) the quantitative (always-peer) and qualitative (same-peer) consistency of partner rearing which correlates with social clinging. Those animals reared without quantitative (To-Ap) or qualitative (Ch-To) consistency or without partners (So-Is) clung less to other
animals than did subjects always reared with the same partner or partners (To-To and So-Gr).

Although aggression correlated with partner number, its release appeared to be regulated by another factor. In the group or stimulus situations, when either one of the pair of subjects from the 1-partner groups launched an attack or threat of attack, the age-mate usually responded in kind. In the peer-adult-stimulus situation this served to prolong aggressive encounters. This same social facilitation, cooperative aggression, or ‘togetherness’, was seen in the 5-partner groups but to a much lesser extent. Also the initiation of agonistic encounters was much less frequent in the So-Is group was similar to that of the 1-partner groups, but there was little social facilitation. Therefore a defeated or dominant social isolate was less likely to reinitiate an aggressive encounter than the To-To and To-Ap group members toward either adult or juvenile stimulus animals.

The findings of the present study are in partial disagreement with a study briefly described by Harlow (1969). He reported on six months of test data on two pairs of To-To females and one group of four subjects reared in a So-Gr from birth and compared their behaviour to monkeys reared on surrogates and monkeys reared with mothers. All subjects had daily intra-group peer social experience in groups of four. Social clinging was abnormally high in To-To animals. Positive social behaviours such as play, and assertive behaviours such as threat were low in both To-To and So-Gr monkeys.

These To-To and So-Gr groups exhibited much stronger social clinging patterns than To-To and So-Gr infants in the present study, illustrated by resulting loss of balance in To-To monkeys and inability to locomote when clinging (Harlow & Harlow, 1965, pg. 301). It is believed that starting the grouping at birth accounted for some of the differences between the results of Harlow (1969) and the present study. This is supported by the age effects reported in the present study.

Alexander (1966) reared infant monkeys from birth for 8 months with only their mother. After separation from their mother these monkeys did not show incapacitating amounts of peer-peer clinging or hyperaggression. Normality of the mothers in promoting independence or separation from the maternal rearing partner may account for these results.

There has been some controversy concerning the effects of social clinging on more complex social behaviours. Often in a group, play appears to vary as an inverse function of clinging behaviour (Mason, 1963). It has been alternately stated that “tight mutual cling (interferes) with more complex social responses such as play...” (Harlow, 1969), and that the contact of
an infant with its mother or a surrogate facilitates later exploration and more complex interaction with the social and nonsocial environment (Harlow, 1958). Moreover the "negative responses of the mother assist the infant in gradually breaking its dependency relationship to her, a necessary step in the socialization process..." (Harlow, 1966). In this study the subjects of the To-To and So-Gr experienced less frequent and less forceful rejection before the age of five months and yet the latter appeared to have successfully broken their dependency upon the group members. These animals, raised in a group of six, exhibited the greatest amount of socially directed clinging and also the greatest amount of self- and social play of all the groups in both playroom-group and stimulus testing. The groups with the least social cling (Ch-To and So-Is) or least total cling (Ch-To) did not show the most self- or social play. In fact, both the So-Gr and Ch-To groups, while showing divergent cling patterns, were remarkably like monkeys reared with mothers and peers in the laboratory and very similar in play patterns. They were such playful and nonaggressive animals that they were used by other experimenters as stimulus and therapy animals.

It might better be stated that whereas an increase in social cling, because of the exclusiveness of behavioural categories, usually coincides with a decrease in play within any given group, variables other than the overall amount of social cling might better predict the amount of play behaviour exhibited when observing several groups with different rearing conditions. As we have seen, social cling is produced by rearing subjects consistently with the same cage-mate(s), but play increases as a function of the number of cage-mates during the rearing process.

SUMMARY
To analyze the antecedent conditions of the together-together syndrome, 6 subjects were reared in pairs, 6 in pairs separated on alternate weeks, 6 in pairs which changed in composition weekly, 6 in a group of 6, and 6 in individual cages. When tested in groups of 6 during the first year of life and with infants, juveniles, and adults during the second year of life, it was found that (a) self-play and social play increased and self-cling and aggression decreased as an increasing function of the number of rearing partners; (b) social cling was greatest in subjects reared constantly with the same animals, and was independent of the amount of play exhibited by a group.

REFERENCES

Behaviour XLVII
CHAMMVE, REARING INFANT Rhesus TOGETHER


RÉSUMÉ

Afin d'analyser dans quelles conditions se produit la façon typique de se tenir embrassés (soi-même ou d'autres), on a élevé 30 singes en 5 groupes de 6. Dans un groupe, les sujets ont été élevés par paire, dans un autre on a séparé les paires par semaines alternées, dans un suivant on changeait la composition des paires toutes les semaines, dans un autre encore on a élevé les 6 sujets ensemble, et les 6 derniers dans une cage individuelle. Après les avoir testés en groupes de 6 pendant leur première année de vie et ensuite, après les avoir mêlés à des tout-petits, des jeunes, et des adultes pendant leur deuxième année de vie, on a découvert que (i) d'une part le temps passé à jouer seul et en groupe s'est accru et que, d'autre part, leur autodépendance physique et leur agressivité ont décru en fonction, de l'accroissement du nombre de partenaires d'élevage; (ii) la dépendance physique du groupe était la plus forte parmi les sujets élevés constamment avec les mêmes animaux, et n'avait aucun rapport avec la quantité de temps passé à jouer, telle qu'on pouvait l'observer dans un groupe.
CROSS-SPECIES AFFINITY IN THREE MACAQUES
Arnold S. Chamove and Harry F. Harlow – University of Wisconsin Primate Laboratory

Forty-six macaques were choice-tested for species preference subsequent to periods of infant social experience with members of one or more of three species. Evidence was found for attachment to the first (3–9 months) species but not to later (9–15 months) species whether the same species but different animals or different species. Monkeys appear to have some innate preference for their own species, at least as objects of certain behaviours.

In 1966, Robert Cairns hypothesized that mammalian attachment bonds are formed as a function of (a) the state of the subject, (b) the reinforcing properties of the stimulus, and (c) the proximity between the subject and stimulus, where proximity is defined in terms of contiguity over time and salience of the stimulus. The hypothesis continues, stating that attachment is therefore facilitated when the subject is young, when there is contact between the subject and the stimulus, and when the stimulus supplies some nutrient requirement of the subject.

Support for parts of this hypothesis has been reported by Cairns (1966, and Cairns and Nakelski, 1971) primarily using dogs and goats reared with one another; and also by other investigators: See also Lorenz (1970), Fox (1969), Kuo (1967). and, using inanimate stimuli, Candland and Milne (1966) and Harlow (1958). There is evidence that chicks, dyed various colours, imprint on their own colour if raised in isolation (Salzen and Cornell, 1968). Attachment in cats is facilitated if there are fewer nonsocial changes in early life (Rosenblatt, Turkewitz, and Schneirla, 1961). Although it has been reported (Lagerspetz and Heino, 1970) that mice reared by rats preferred their foster-species when adult, Denenberg (1966, 1968) states that mice reared with rats and those reared with mice both prefer rats at 82 days to a greater extent than groups with more extreme rat or mouse experience.

Attachment behaviour in rhesus monkeys has also supported parts of the Cairns' view. Monkeys handled extensively by human beings early in life continue to prefer Homo sapiens to Macaca mulatta for periods up to four years of age (Sackett, 1970). Isolate-reared monkeys do form attachments to inanimate surrogates at age 250 days but they are slower to develop and less persistent than earlier attachment (Harlow, 1958). Also, clinging behaviour is less intense and less frequently observed in infants paired after three months of age than those paired earlier (Chamove, 1973). In fact Harlow, Harlow, and Dodsworth (1966) report that infant rhesus form strong attachments to quite brutal 'motherless mothers'.

Rhesus seek proximity with (Sackett, 1970) and open a door to look at (Gallup, 1966) other rhesus more than other macaque species. Sackett also found that feral rhesus, stumptails, and pigtailed all preferred to remain close to their own species. They report no main effect of sex of subject or interaction of sex of subject with species or stimulus monkey. Rhesus, reared

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2. Currently at Stirling University Psychology Primate Unit, Stirling, Scotland, FK9 4LA, where reprint requests may be sent.
singly in a colony room, preferred to proximate rhesus when under a year of age. Older rhesus, having had some physical social contact with rhesus, did not show a rhesus preference.

In the present experiment I use three species of monkey of the genus Macaca and vary degree of contact, number of attachment species, and age when measuring attachment between these species. These three species, although closely related, differ subtly, though noticeably in looks, in communicative gestures, and in temperament. We seek to ascertain whether these variables will affect attachment and the malleability of that attachment when the different attachment objects differ so little but nevertheless do differ visually in a species for which visual cues are so important.

Method

Subjects

Twenty-four rhesus (Macaca mulatta), four stump tail (Macaca arctoides), and eighteen pigtail (Macaca nemestrina) were separated from their mothers at birth and reared alone in cages (as described by Blomquist and Harlow, 1961) for three months. At that age the experimental conditions were begun. From birth until Period III, animals were housed, in a colony room where they could hear and see other monkeys, always rhesus, in adjacent cages.

Apparatus

The monkey subjects were housed from birth in cages 0.46 x 0.61 x 0.61 m. Paired infants were housed in two of these cages placed back-to-back. The enclosure for monkeys housed in a group of 12 measured 1.5 x 1.5 x 2.1 m. Testing was performed in a Sackett Self-Selection Circus (Sackett, 1970). Hexagonally shaped, it consisted of a central start compartment bounded by six choice compartments in turn surrounded by six stimulus-animal compartments, the three alternative segments of which were used in this experiment. From the start compartment an animal could see, through three perspex doors, all three stimulus monkeys. When the doors of the start compartment were raised, it could approach one of the stimulus monkeys while seeing it through the remaining two clear doors and then remain near it.

Procedure

The infants were divided into six groups. At three months of age, Period I was begun. It consisted of specialized housing lasting six months followed by circus preference testing of all animals. Period II, from age 9 to 15 months, consisted of housing and final testing of 24 animals. And Period III, using only 12 subjects, involved housing from 15 to 21 months of age and a final preference test.

Testing

All groups were first preference tested when nine months of age in the circus. Groups 3 – 6 (described below) were also tested there when 15 months of age and certain members of Group 3 – 5 were also tested when 21 months of age. Testing consisted of placing the subjects living together into separate transport cages, putting one monkey into the central ring of the circus for five minutes of adaptation and ten minutes of testing where the subject could leave the central area and enter into any of three arms of the circus and thereby approach to within 0.7 cm. of either one of the three stimulus monkeys. These three male stimulus monkeys were similarly-reared unfamiliar age-mates of the subject; one was a rhesus, one a stump tail, one a pigtail. A record of the number of entries and the duration of time spent in each of the three arms was manually recorded on clocks by means of a television unit.
Cross-Species Affinity in Three Macaques

Housing. Groups 3—6 were housed in cages with other monkeys starting at three months of age in pairs which never changed composition from age three months until nine months of age. The pair members were then changed and thus maintained for another six months. Subsequently, four monkeys from each of Groups 3—6 were housed in a single group of twelve monkeys for six months during Period III. Groups are described in Table 1 and as follows.

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Table 1

Number of subjects of each species in each group (left), and the pattern of pairing in the first two periods (right). The asterisks indicate those subjects comprising the mixed group of sixteen subjects in Period III.

1. Rhesus Group. Group 1 was composed of 16 rhesus monkeys, tested daily in a playroom in groups of four for 30 minutes with other rhesus. They lived alone in the colony room.

2. Visual Group. Members of Group 2, 16 pigtails, were individually housed in cages adjacent to rhesus monkeys. For six months they could only but always see rhesus.

3. Own-other Group. Two rhesus and two pigtails comprised Group 3. Each was pair-housed with a monkey of its own species during Period I and another species, not its own, during Period II.

4. Other-same Group. Members comprising Group 4, six rhesus, two pigtails, and two stumptails, were housed with a member of species other than their own during Period I. During Period II, they were housed with a different monkey but with a monkey of the same species as that of their partner in Period I.

5. Other-different Group. Members of Group 5, two rhesus, two stumptails, and two pigtails, were housed with member of a species other than their own during Period I. In Period II, the housing partner was a member of a different species from that of the subject and of the partner of Period I.
6. **Other-own Group.** Group 6 was composed of a total of two rhesus and two pigtails. Each animal was housed in pairs during the six months of Period I with a species other than its own, and housed during the six months of Period II with a member of its own species.

**Analysis.** Unequal Ns analyses of variance were performed on duration scores. Three analyses were used, one for each Period or test block. Analyses were Group X Choice, with three levels of choice as depicted on the abscissa of Figure 1.

**Results**

As seen in Figure 1, (a) monkeys reared from age three-nine months with their own species (Group 3), (b) rhesus having 30 minutes daily social experience with their own species between three and nine months of age (Group 1), and (c) pigtails reared from birth seeing only rhesus (Group 2), all significantly prefer (by a factor of two-three times) to proximate that species of macaque when preference tested at age nine months. Also (d) animals reared in pairs with other species show stable preferences for that species when tested at nine months. But those changed at nine months from their own to another species, or changed from another to their own species, or changed from another to a third, species, do not show consistent preferences.
Cross-Species Affinity in Three Macaques

for members of their own, the most recent, or the less recent partner species when tested at 15 months of age. Testing after six months of subsequent housing in a mixed group of 12 did not yield significant preference effects when looking at own species, most recent single other species with which housed, or other species housed with still earlier or never before.

This was revealed in a significant Group X Choice interaction (p<.01) in Period I and by a subsequent Fishers LSD test showing all groups preferring the monkey last with when paired. No other analyses revealed significant variance ratios.

Discussion

This study supports part of the Cairns hypothesis in that it was found that subsequent to a period of six months early in life, monkeys prefer that species of monkey most salient in its environment (solid circle symbols throughout Figure 1). This was seen in 20 animals housed with monkeys of a different species, and in monkeys given more brief social experience with animals of the same species. However, these preferences were not maintained after an additional six months either in the situation when the species of the partner remained constant (Group 4) or when the species was changed, either to the subject’s own species or to a third species; but, notably, they were not shifted to another species.

The visual contact of all the colony-reared animals with rhesus during and after the first three months of life may have lead to some amelioration of other preferences, as suggested by the strong effects of the Visual Group. Also, there is the possibility of the development of specific, i.e., individual, preferences over-shadowing those of species and due to the subject’s experience with only one animal of a given species. This is supported by evidence from or can account for the findings of the Other-Same group, Group 4.

The manipulations of paired housing were observed to be quite effective in the rapid development of affiliative behaviour patterns between the pair members. Within a month of pairing at age three-months and re-pairing at nine months of age, the new partners were observed to sleep huddled together and would rush together after the brief forced separation concomitant with animal maintenance procedures. Affiliation at nine months was less rapid, probably due to the absence of the former partner (Chamove, 1973), and was accomplished with a minimum of bloodshed.

Observation of the mixed species group of 12 in Period III illuminated one consistency: The monkeys would sleep huddled with their previous rearing partner, but playful interaction occurred almost exclusively with members of their own species, a species with which until that time eight members of the group had never been allowed to interact. This was noted especially in the dominant animals of the group — a male and female stump tail, the animals next in the hierarchy — two female pigtails, and in another pair of pigtails and pair of rhesus. The playful stump tail pair exhibited mutual behaviours never seen in pigtail or rhesus monkeys such as face slapping and handling of genitals, (reported in Bertrand, 1969, for stump tail-reared stump tails).

The rhesus of this study seemed quickly to learn to withdraw from the hostile lipsmack of the pigtails instead of responding by approach to what in rhesus language would be an affiliative or appeasement gesture, while still using the lipsmack in a manner appropriate to rhesus. The formation of the group of 12, probably as a function of the age of the monkeys, their abnormal early rearing in pairs, and in several cases the presence of their former partner, was accompanied by much hostility. In a smaller enclosure, death would most certainly have been the fate of the smallest four group members. Aggression toward these more immobile
monkeys continued at least sporadically until final testing, although it appeared that a living arrangement had been achieved.

It is clear that animals and certainly primates develop an attachment for an alien species when given exclusive experience with that species early in life. The specificity, malleability, or permanence of that preference is not so clear.

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Therapy of Isolate Rhesus: Different Partners and Social Behavior

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The behavior of animals reared under varying degrees of isolation is often quite bizarre. The permanence and extent of these patterns has been shown (Bronfenbrenner 1966) to depend upon the particular behavior measured, the duration of isolation, the age at which isolation is begun, and the phylectic level of the subjects. Bronfenbrenner reports that total social isolation of insects or fish from birth to maturity produces no detectable irreversible social deficit. However, in birds, rodents, dogs, and primates, social isolation has been shown to damage the animal permanently. Total social isolation for over 3 months produces long-lasting but circumscribed debility in rhesus monkeys, whether started at birth, 3, or 6 months. Longer periods—9, 12, or 14 months—when started at birth, have drastic and presumably permanent social effects. Partial social isolation, allowing monkeys to see and hear but not physically interact with others, produces less of an effect than total isolation (reviewed by Mitchell 1970).

Work with both forms of isolates has, in the main, been descriptive and evaluative rather than rehabilitative, but suggestions as to possible rehabilitative procedures are evident. These experiments most commonly grouped various types of isolates with age-mates of either greater, equal, or lesser social experience. A study by Rowland (reported by Mitchell 1970) tested monkeys daily in a playroom subsequent to removal from isolation. He tested four control animals, which were 1-year partial isolates, with four 1-year total isolates in groups of four. He also tested four additional 1-year partial isolates with four 6-months late total isolates, monkeys isolated between 6 and 12 months of age. It is important to note that his two "control" groups, the eight 1-year partial isolates, showed behavior patterns divergent from one another as a function of the behavior of their total isolate partners. The extreme aggressiveness of the 6-months late total isolates can account for the high-level, negatively accelerating function of disturbance and a mirrored low level of social approach in the 1-year partial isolate controls. Similarly reared 1-year partial isolate controls tested with the fearful, disturbed, unassertive 1-year total isolates showed low and negatively decelerating disturbance scores from the very beginning of testing and high positively accelerating social approach scores, as well as a great deal of aggression. Because of

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this high level of aggression, testing was terminated at 10 and 12 weeks, respectively.

A subsequent study by Pratt (also reported in Mitchell 1970) briefly tested 9-months total isolates with sophisticated age mates and/or 9-months partial isolates both in triads and quadrads, observing each subject's responses differentially to the type of partner. He found social fear higher, but nonsocial disturbance lower, when either type of isolate was paired with the social sophisticates. Levels of nonsocial play, social threat, and social explore were not a function of partner type.

A final type of evaluative study is typified by Mitchell (1970), who briefly paired monkeys of varying rearing histories with socially sophisticated adults, age mates, or younger, juvenile stimulus monkeys. When comparing 1-year total isolates to animals reared with maternal and peer interaction, he reports that play and hostility were primarily directed toward the juvenile stimulus monkeys by the isolates but directed toward age mates by the mother-peer group. The absolute levels of these behaviors further differentiated these two groups.

Chamove (1973) tested six 11-month partial isolates with an infant, younger juvenile, or adult in a similar situation to that described above. Aggression increased with the age of the stimulus animal.

Therapy of isolated monkeys has been reported by three groups of experimenters. The first was Harlow and Harlow (1962), who placed a sex-balanced group of 18 monkeys, 3-4-year-old partial isolates, on a monkey island for 2 months. They reported some positive behaviors after an initial period of "misunderstanding"; social grooming and pair bonds developed but there was no sign of normal sexual behavior even after the introduction of their "most experienced, most patient, and most kindly breeding male."

Arling (reported in Mitchell 1970) found no improvement in the behavior of inadequate isolation-reared motherless mothers toward their second infant above that which could be accounted for by age in these now more experienced mothers.

In an attempt to treat one of the symptoms of the total isolate—the reluctance to physically contact other monkeys—isolates were successfully trained to avoid shock by sitting on a small platform in contact with another monkey in a shuttle-box. But subsequent playroom testing did not reveal any stable improvement in the isolates' contact scores (Sackett 1968).

Another study, subsequent to the one reported herein, was therapeutic in design. Four 6-months total isolates were first paired and then grouped with socially sophisticated monkeys 3 months their junior. The authors report almost total recovery within 9 months (Harlow & Suomi 1971) in that the isolates did not differ from the therapists, the only control group used.

The purpose of the present study was to pair monkeys suffering from a moderate level of social deficiency with one of two types of rehabilitative agents. The first type was the 3-month infant, at an age when social play is beginning its rapidly accelerating development in terms of both frequency and complexity but too young to challenge the dominance of the older and larger isolate monkey. The second type was the socially sophisticated age mate, of an age when play is complex and frequently exhibited and having sufficient experience to cope with any hostile behavior in the isolate subject. It was expected that with the infant both the therapist and partial isolate patient could develop together, whereas with the socially sophisticated therapist the patient would be rewarded when affiliative and punished when aggressive. A third group, partial isolates paired with partial isolates, served as a comparison group. The effects of being a therapist were also assessed by using a complete factorial design. In addition, rather than evaluating the results by comparing the groups on some global measure of adequacy, groups were assessed as a function of changes in individual behaviors.

Method

Subjects.—Twelve 9-month-old rhesus monkeys (Macaca mulatta), formed the Patient group. They were separated from their mothers at birth and reared in bare wire cages as described in detail by Blomquist and Harlow (1961). During the first 9 months of life, these monkeys had visual and auditory but no tactual contact with other animals. After 9 months of partial isolation rearing in a colony room each of these "patient" subjects was assigned to one of three "therapy" conditions: (a) Four of the previously isolated subjects were paired daily with the 3-month-old infant "therapists," and these were termed the
Patient-developmental subgroup; (b) four of the partially isolated animals were paired with socially sophisticated age-mate therapists and were designated the Patient-sophisticate subgroup; and (c) the four remaining monkey isolate patients were paired with socially naive age-mate therapists, that is, other patients, and these were termed the Patient-patient subgroup.

The therapist monkeys mentioned above were animals of three types: (a) Four were 9-month-old socially sophisticated monkeys which had been housed in changing pairs from 1 month of age (see Chamove 1973); (b) four were 3-month-old infants which had as yet had no social experience (called developmental); and (c) four were 9-month-old socially naive patient monkeys, which were also used as experimental subjects. All were separated from their mothers at birth and reared in bare wire cages until the start of their experimental treatment. To assess changes in the therapists as well as the patients, a factorial design was used pairing independent subgroups of each of the three types of monkey groups with one of each of the other types. This meant that not only were four patients put with infants (Patient-developmental), four with patients (Patient-patient), and four with sophisticates (Patient-sophisticate); but also four infants were put with infants (Developmental-developmental), four with patients (Developmental-patient), and four with sophisticates; and similarly for the 12 comprising the sophisticate group.

Table 1 gives the design for the three patient subgroups. The designs for the infant and sophisticate groups are identical so that from each of the three groups of 12 animals, four subjects were paired with developmental infants, another four with patient, and the final four with sophisticated 9-month-old monkey therapists, a 3 x 3 design with four subjects per cell and utilizing a total of 36 macaques. Sex was randomized in that animals were assigned to groups as they were born with no regard as to sex except that many of the males were removed for use in biochemical studies. As a result there were only two males in the Patient group and three in both the Developmental and Sophisticate groups.

Table 1

<table>
<thead>
<tr>
<th>Patient Subgroups</th>
<th>N</th>
<th>During First 10 Test Sessions</th>
<th>During Final 10 Test Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient-sophisticate</td>
<td>2</td>
<td>Sophisticate</td>
<td>Patient-developmental</td>
</tr>
<tr>
<td>Patient-developmental</td>
<td>2</td>
<td>Developmental</td>
<td>Patient-sophisticate</td>
</tr>
<tr>
<td>Patient-patient</td>
<td>2</td>
<td>Patient</td>
<td>Patient-developmental</td>
</tr>
</tbody>
</table>

Note.—Columns 1 and 2 denote the subgroups name; column 1 is the rearing condition; column 2 is the therapy condition; column 3 is the type of animal with which the patient was grouped for the first 10 playroom test sessions; columns 5 and 6 describe the type of animal with which the patient was tested for the second 10 test sessions. The format for the other two groups, i.e., Sophisticate or Developmental rearing condition, is the same when the capitalized words “Sophisticate” or “Developmental” replace the word “Patient” throughout.
of a synchronous motor-microswitch apparatus.

Recording of behaviors and their duration was performed by the simultaneous use of a one-pen event recorder and a check sheet. The experimenter observed each subject for three periods of 5 min, continuously recording the behavior of that subject within each 5-min period, so that duration values for the behaviors were obtained. The apparatus for recording is described in Chamove (1974). The behaviors recorded were: socially directed withdrawal, explore, play, and hostility, and the same behaviors nonsocially directed. Whether monkeys were in physical contact with each other was also recorded. Detailed definitions, reliability, and rationale for choice of behavior categories are given in Chamove, Eysenck, and Harlow (1972).

Procedure.—Beginning at 9 months of age, animals were given therapy for 4 continuous hours daily between 10 A.M. and 2 P.M. for a total of 20 consecutive weeks. Either two therapists were placed in the patients' home cage one at a time, or, on alternative days, patients were placed in identical cages housing one of the two therapists. All subjects were paired daily with one of the two other animals in an unsystematic order. Animals received no other social contact than in the daily therapy and weekly test situations although, being housed in the colony room, they could hear and see other monkeys.

In summary, 12 monkeys reared in partial isolation for 9 months were termed the Patient group. One-third of these were paired daily, each with one of two infants, and were designated the Patient-developmental subgroup; one-third, paired only with sophisticates, were called the Patient-sophisticate subgroup; and the final four were paired with each other and called Patient-patient animals. In addition, those four infants or Developmental therapists paired with patients were called the Developmental-patient subgroup; those four monkeys from the 9-months Sophisticate rearing group that were paired with patients (i.e., given the patient treatment) were termed the Sophisticate-patient subgroup.

The experiment was designed to run for longer than 20 weeks, but unfortunately it had to be terminated for reasons outside the experimenter's control, the animals being reassigned to a biochemical experiment.

Social testing, in weekly, hour-long evaluation sessions conducted in the playroom, began after the first week of therapy and continued for the total period of 20 weeks. During the first 10 weeks of testing, a given animal was tested once a week with its two therapists plus one other animal from its rearing condition. This particular combination was chosen in the belief that using familiar therapists would facilitate social interaction in the playroom evaluation sessions. By 10 weeks it was clear that this was not always the case. Hence, in the second 10-week period the evaluation procedure was changed. All animals were tested once a week in a group only with animals from the same rearing condition. Therefore, in the first half of the 20-week testing period a Patient-sophisticate monkey would be tested with one other Patient-sophisticate and two Sophisticate-patient therapist monkeys; in the second half, however, that same Patient-sophisticate isolate would only be tested with three other isolates (the same three other isolates throughout the 10 weekly sessions, as seen in table 1). Because animals were evaluated only with others from the same rearing condition, it was felt that this second 10-week block of testing was better for assessment purposes.

A total of nine analyses of variance, three for each group, were performed on duration scores collected during playroom testing. Behavior categories were combined into six behaviors called social explore, nonsocial explore, social play, nonsocial play, fear, and hostility. The categories were paired for analysis, the first analysis called "explore" having social and nonsocial direction as a correlated variable in the analysis. Combining of categories functioned to help retain alpha per experiment by reducing the number of analyses. The second analysis also utilized social and nonsocial play. The third analysis was called "agonistic," and fear and hostility were used as the behaviors. The 10 test days of each half were collapsed into three blocks: block 1 was composed of the first 3 days, block 2 of the next 4, and block 3 of the final 3 days of the half. The analysis of variance used on each group was therefore a 3 (subgroup) × 2 (halves) × 3 (blocks) × 2 (behavior) analysis containing repeated measures in the halves, blocks, and behaviors dimensions. Subsequent Fisher's least significant difference (LSD) tests were employed to make finer comparisons between the means revealed as significant beyond p = .05. All results reported are significant unless specifically stated otherwise.
Results

Isolates.—Those partial isolate patients paired with sophisticated peers showed the most normal development of social behavior of all the isolates, and those isolates paired only with other isolates showed the least normal development. The analysis of play behavior yielded a significant subgroup × halves × behavior interaction. A subsequent Fisher's LSD test showed that the sophisticate-paired isolates exhibited significantly more socially directed play (LSD = 2.1) and more nonsocially directed play (LSD = 6.0) than the other two groups in the first half of testing (see fig. 1). The significantly greater amounts of social play by the infant-paired isolates in half 1, block 1, when compared with the isolate-paired isolates, the subsequent reduction in play, and its partial recovery in half 2 are unexplained. During the second 10 weeks of testing isolate-paired isolates showed significantly less of both types of play and the Patient-sophisticate showed significantly more social play than did the other isolates. The significant drop in nonsocial play in half 1, block 2 by the Patient-developmental partial isolates seems related to the high level of agonistic behavior seen in this group in that particular block. The Patient-patient subgroup show significantly less nonsocial play than the others by the final block of testing.

The analysis of agonistic behaviors revealed a significant subgroups × halves × blocks effect, as illustrated in figure 2. Interpretation of this interaction was that fear behavior was significantly greater in block 3 of the first half of testing in the Patient-patient subgroup than the other two subgroups (LSD = 3.7) as well as throughout half 2. Hostility differences showed a development parallel to that of fear with the following two exceptions: hostility was very low during the first block of testing; hostility was significantly less in infant-paired isolates than in other isolates in the second half of testing. Patient-patient monkeys were significantly more hostile to other Patient-patient monkeys in the second half of testing than were the other Patient subgroups (LSD = 7.4).

Sophisticates.—The Sophisticate monkey group showed only one significant subgroup effect. That was a subgroup × block × behavior interaction in the agonistic analysis (de-
picted in fig. 3). Hostility doubled in all sophisticated monkeys between halves but, as this did not interact with subgroup, it is not shown. Within the test halves, hostility decreased significantly for all groups except the isolate-paired sophisticateds. Also, this subgroup showed significantly more hostility than the others throughout testing (LSD = 3.9). Fear was rarely exhibited in the sophisticate group.

Developmental.—The infant group showed differential effects of pairing in two analyses as presented in figure 3. There was a subgroup x halves x behavior effect and a subgroup x behavior effect in the agonistic analysis. Isolate-paired infants were significantly more hostile in the second half of testing, when tested only with infants, than in the first half, when with both infants and older isolates, and significantly more hostile than the other two developmental subgroups (LSD = 0.59). In the play analysis significant effects were seen in the subgroup x behavior and in the subgroup x halves x behavior interactions. Social play was significantly less frequent and nonsocial play significantly more frequent in Developmental-patient subjects in half 2 than in Developmental-developmental and Developmental-sophisticate infants (LSD = 11.1).

No differences were detected by the exploration analysis in Developmental, Sophis-

Un fortunately, these results did not enable us to evaluate most of the different models of aggression production (Eron, Wald er, & Lefkowitz 1971). The Catharsis model,
primarily concerned with aggression in the adult, predicts the least aggression in animals paired with infants, and this was found. The Modeling model, primarily concerned with aggression as it develops in the infant or juvenile, predicts the greatest aggression in animals paired with isolates, and this was found. The Frustration-aggression model predicts least aggression in infant-paired animals, also found as described above. A Learning or Instrumental model, assuming an infant would positively reinforce aggression and a sophisticate would negatively reinforce it, predicts higher levels of aggression in animals paired with infants than in those paired with sophisticated peers. The reverse was found.

The home-cage behavior of the isolates toward other isolates was one of increasing fear in the subordinate and increasing hostility in the dominant partner. Hostility was the predominant initial behavior toward the infant, so much so that the experiment was termed the "infant elimination study" by the animal caretakers. Despite the prolonged periods of infant vocalization, these monkey therapists were not injured by their partial isolate partners, the latter soon appearing to tire of their nonresisting companions. Other isolates, when paired with isolates, fared less well, emerging from their 4 hours of therapy with bruised eyebrows, tails, and digits. This agrees with reports of isolates subsequently housed in groups by Chamove (1973) and isolates only tested in groups by Rowland described above. Isolates paired daily with sophisticated therapists were, as predicted, quite subordinate to them, withdrawing at first from even playful encounters in the close quarters of the home cages. Later, however, rudimentary play patterns were seen to be developing.

In the playroom there was a significant increase in positive contact behaviors similar to that reported in chimpanzees but also an increase in total interaction unlike the chimpanzee results (Turner, Davenport & Rogers 1969). Upon closer analysis the increase in total interaction of our partial isolate rhesus was found to be mainly a result of a large increase in noncontact behaviors. Their contact behavior increased in parallel with that of other groups, while their noncontact behavior increased at a more rapid rate.

Although the ever-lowering hostility of partial isolate patients paired with developmentally naive infant therapists lends support to a cathartic explanation of aggression reduction, hostility toward socially isolated age mates (see Rowland above and Chamove 1973) appears to persist undiminished over a period of weeks until the combatants are separated. The hostile partial isolates appear to engender similar hostile patterns in sophisticated and also in developing infants, hostility suppressed in the infants when with the partial isolates but emerging when the infants are later tested with peers. As the expression of fear militates against play behavior, it is not surprising that those Patient-sophisticate isolates showing lowest fear scores also played the most. The strong relationship among hostility, fear, and play can relegate hostility scores to a limiting role in relation to social play, and likewise high fear scores often limit the expression of both hostility and play. But we have also seen that varying partner type can alter these behaviors independently.

We may therefore conclude that forced contact leads to behavior change, the greater change occurring in the least sophisticated monkeys. The data here suggest that the partial isolation syndrome may be due more to interference from emotionally based responses during or soon after isolation than to the more commonly suggested absence of learning critical skills during critical periods.

These data are compatible with the following speculation. If an acquired behavior pattern were adaptive and there were no direct way in which this behavior could be transmitted genetically, it would seem advantageous for a mother or guardian to have some mechanism whereby this behavior could be passed on. One way of doing this would be to program infants genetically to copy indiscriminately the behavior patterns of their mother which were exhibited by the mother during the early period of mother-infant attachment. One could view this as cultural inheritance of acquired behavioral characteristics—the mother is brutal and aggressive, either toward the infant or toward others, and the infant becomes aggressive.

In this study infants or isolates paired with aggressive isolates became aggressive; isolates paired with nonaggressive infants became the least aggressive; isolates paired with playful sophisticates became the most playful. The specificity of transmission of specific behaviors suggests that young monkeys copy specific behavior patterns.
References


Social Preferences in Stump-Tailed Macaques (*Macaca arctoides*): Effects of Companionship, Kinship, and Rearing

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Social preferences in the directionality of social behavioral patterns in a heterogeneous group of 26 stump-tailed macaques (*Macaca arctoides*) were examined to see if kin recognition occurred. Four behavioral measures were analyzed: proximity, contact, grooming, and play. Three independent variables were examined: early companionship, condition of early rearing, and kinship. The latter was divided into patrilineal, matrilineal, and shared kinship. Partial correlational analysis showed that social preferences correlated most strongly with companionship, followed by kinship and rearing conditions. Within kinship, patrilineal and matrilineal effects differed markedly, suggesting that natural selection has operated differentially in a species in which normal child-rearing is done by matrilineal kin.

Studies of kin recognition are burgeoning: The phenomenon of an individual being able to recognize a close relation has been shown in a range of species from sweat bees to primates (Holmes & Sherman, 1983). Such abilities provide the most likely mechanism for the operation of kin selection (Hamilton, 1964). In order for an organism to invest selectively in relatives (i.e., nepotism), it must first be able to distinguish kin from non-kin. Furthermore, in order to optimize investment over kin of varying degrees of relatedness, it is useful to differentiate among them (Weigel, 1981). Thus, a genotype that is more efficient at kin recognition is advantaged in terms of natural selection over one that is less efficient.

In practice, the ability to recognize kin often co-varies with at least two other variables: familiarity with early companions and shared conditions of early rearing. Either of these may account for social preferences shown by individuals in later life (e.g., Pratt & Sackett, 1967; Walters, 1981). In the field, such potential interactions between variables are hard to control for, and often all three could explain findings. For example, the find-
ing that rhesus monkey (*Macaca mulatta*) brothers form alliances after leaving their natal groups (Meikle & Vessey, 1981) could be explained by kin recognition, or by familiarity through bonds of matrifocal attachment, or by common experience, such as growing up in a small (or peripheral, or well-fed, etc.) rather than a large (or central, or poorly fed, etc.) troop.

In the laboratory, the appropriate variables can be manipulated, but usually at some cost of artificiality. Wu, Holmes, Medina, and Sackett (1980) demonstrated that young pigtailed monkeys (*Macaca nemestrina*) preferred their half-siblings to unrelated peers when both stimulus monkeys were strangers. In seeking to eliminate possible companionship and rearing effects, they raised their subjects individually in standardized wire cages. Wu and colleagues’ study was limited in several ways: It involved only young monkeys, related only paternally, choosing only dichotomously, having had only abnormal, uniform upbringings. Further, only two minimal measures of social preference were used: visual orientation and approach, i.e., entry into an adjoining compartment. In summary, their study was elegantly but sparsely and homogeneously designed. [An attempt to replicate Wu et al.’s findings, using greater numbers of subjects, was unsuccessful (Fredrickson & Sackett, 1984). They concluded that familiarity alone was responsible for such preferences.]

To what extent do kinship, rearing, and companionship influence social preferences under more generalizable conditions? To test this, we assembled a heterogeneous group of stump-tailed macaques. They varied widely in age and degrees of relatedness, both matrilineally and patrilineally, and had experienced a variety of rearing and social conditions from early isolation in a small cage to being mother-reared in a group in a large cage. A full battery of social behavioral measures was used. Though far from natural, the resulting conditions showed a rich complexity. The aim of the study was to use partial correlational techniques to tease out the sometimes confounded influences that result in the expression of social preferences. Further, because there is some evidence for macaques that the effects of paternal and maternal kinship differ (Small & Smith, 1981), we differentiated among matrilineal, patrilineal, and shared kinship. Altmann (1979) has speculated that for polygynously mating species, age cohorts of paternally related half-sibs may be expected, and that these paternal sibships may enhance selection for sibling altruism more than do maternal sibships.

**Methods**

**Subjects**

The subjects were 26 stump-tailed macaques (*Macaca arctoides*). All were born in captivity, and 15 were females and 11 were males. They ranged from 7–94 months in age at the start of the study: Three (19,2♂♂♂) were infants (younger than 18 months), 17 (9♀♀,8♂♂♂) were immature (aged 18–39 months), and 6 (5♀♀,1♂♂) were adults (aged 40 months or more).

All lived in one group, but earlier they had been reared in various conditions and sizes of groups. For analysis, each monkey was classified into one of three rearing conditions, based on its first 10 months after birth: *Mother-reared (M) =* reared by natural or foster mother, with others in a group (*N = 6*); *Peer-reared (P) =* reared, part-time or full-time, with two or more peers (*N = 9*); *Dyad-reared (D) =* reared with one peer, or mirror-image (*N = 11*). For comparisons of rearing in analysis, pairs were classed as *similar* (M-M, P-P, D-D) and assigned a score of 1; *somewhat similar* (M-P, P-D) and assigned a score of 2, or *dissimilar* (M-D) and assigned a score of 3.
The classification of early companionship for a subject was based on those monkeys with whom it lived during the first 18 months after birth. Companions were ranked from most to least time spent living together in this period.

Because of their varied life histories, each subject had both familiar and unfamiliar kin and nonkin. Matrilineal kinship was known from births; patrilineal kinship was based on the alpha male in the group at the time of conception. (Previous observations indicated that only the alpha male mated to ejaculation, in this species unique among macaques in having a copulatory “tie.” Even if some cases of paternity were misclassified, the bias is a conservative one in this study.) Of the possible 325 dyads, 128 shared patrilineal genes and 28 shared matrilineal genes; of these, 10 shared both. Within related dyads, coefficients of relatedness varied from .0625 (half-cousins) to .50 (full sibs).

Apparatus

During observations, the monkeys occupied a large, covered outside area (2.6 x 5.4 x 3.7 m). It had a cement floor, covered in wood chips to a depth of about 5 cm, and contained mesh and tubular climbing surfaces as well as movable play items, e.g., plastic barrel, rubber tire. Adjacent to the area housing the monkeys was a darkened observation room in which the observer (MacKenzie) sat and observed through a glass window. Chamove (1981) gave details of housing and husbandry, but in brief, the group was formed from consecutive births in the colony. Most of the monkeys joined the group when they reached 18 months of age and were accompanied by their rearing mates.

Data were recorded on a nine-key, numerical keyboard that produced an output in punched paper tape. Each datum was coded in terms of five numbers, which referred to behavioral category and subcategory and to performer and recipient. Duration and frequency of each bout were recorded automatically by the depression of the keys. The tapes were transcribed onto the university’s VAX computer for statistical analysis by SPSS.

Procedure

Observations were made from 1000-1300 hours, Monday to Friday, over 3 months. Each monkey was observed by focal-subject sampling for 5 min daily; the order of observation was randomized. Overall, 38 records totaling 190 min per subject were completed, but some data were lost due to machine malfunctioning. Differing amounts of data were lost for each subject at random; losses ranged from 25-52% of the observation time, giving a mean of data available per subject of 115 min.

Twenty-eight mutually exclusive behavioral categories that had proved useful in previous studies (e.g., Anderson & Chamove, 1979) were recorded. These were grouped in five classes—affiliation, play, sex, fear and submission, and aggression—and each class included four to seven categories. Only three categories of behavior occurred often enough to be analyzed, since a threshold of at least 80 min of total duration over all subjects was chosen arbitrarily as a criterion for inclusion. For the other 25 categories, either too few instances, or too few subjects, or both, prevented their being analyzed independently. When all six categories of play were combined, they too exceeded 80 min of total duration, and so the whole class of play was treated as another category. We considered all four categories as friendly, and so we took each to indicate social preferences between monkeys, i.e., *proximity* = remaining stationary within arm’s length of, but not in contact with, another monkey; *contact* = physical contact between stationary monkeys, but excluding special cases of huddling, grooming, mating, or aggression; *groom* = pushing back
TABLE 1. Ratio of All Subjects’ Interactions, More/Less Often with Kin or Nonkin, for Friendly Behavior.

<table>
<thead>
<tr>
<th>Behavioral Pattern</th>
<th>Patrilineal Kinship</th>
<th>Matrilineal Kinship</th>
<th>Shared Kinship</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Initiator</td>
<td>Recipient</td>
<td>Initiator</td>
</tr>
<tr>
<td>Proximity</td>
<td>25/1***a</td>
<td>22/4***</td>
<td>9/12</td>
</tr>
<tr>
<td>Contact</td>
<td>21/5***</td>
<td>17/8</td>
<td>8/13</td>
</tr>
<tr>
<td>Groom</td>
<td>14/11</td>
<td>15/11</td>
<td>4/16**</td>
</tr>
<tr>
<td>Play</td>
<td>19/6**</td>
<td>19/7*</td>
<td>10/11</td>
</tr>
<tr>
<td>Totals</td>
<td>79/23</td>
<td>73/30</td>
<td>31/52</td>
</tr>
</tbody>
</table>

152/53 62/105 61/43

* $N = 26$ monkeys, except when ratios were 0/0; i.e., dyads showed no interaction, or when times were equal.
** $p < .05$, Sign Test, two-tailed.
*** $p < .01$.
**** $p < .001$.

another monkey’s hair with one hand while picking off debris, etc., with the other hand or lips; and play = “play-face” alone or combined with chasing, lunging, slapping, wrestling, or mouthing. (*Preference is used here in the sense of the compromise between “pure” preference and competition with others for prized partners.*)

Results

The first calculation was done to answer the question, “Did the monkeys prefer to interact more often with kin than nonkin?” Each possible pair of monkeys was classed as being either patrilineal kin, matrilineal kin, shared kin (with both patrilineal + matrilineal genes), or nonkin, and each participant was further designated as the initiator (i.e., focal subject) or recipient of the behavior. Each monkey, therefore, interacted more (++) or less (−) often with kin than with nonkin (see Table 1). A Sign Test was used to see if monkeys interacted more with kin than would be expected by chance.

For the analysis of patrilineally related kinship, five of the eight Sign Tests were statistically significant and all were in the same direction. More precisely, for proximity and play, both initiator and recipient, and for contact, the initiator showed more of the behavior directed toward patrilineal kin than would be expected by chance. Over all four behavioral categories in Table 1, 152 dyadic interactions were more common between kin and only 53 more common between nonkin.

The analysis for matrilineal kinship was quite different. In only one pair of behaviors was there a significant preference related to kin. For grooming, individuals both initiated and received less grooming with matrilineal kin than would be expected by chance. This pattern of avoidance of matrilineal kin was consistent: Over all dyadic combinations in Table 1, only 62 cases showed preference for matrilineal kin while 105 showed the reverse.

The pattern for shared kinship was mixed and intermediate: Only one of the eight sign tests was statistically significant, with the initiation of play showing a preference for kin. However, for all dyadic combinations in Table 1, only 61 of 104 pairs showed this directionality.
However, other variables may have influenced the direction of the monkeys' affiliative behavior. Two obvious factors were early companionship and early rearing conditions. To assess the relative strengths of the variables of kinship, companionship, and rearing condition, Kendall Rank Order Correlation Coefficients were computed. The main reason for these statistics was to estimate the relative contributions of the five variables to the directional preference of the four behavioral categories, and the correlation coefficient is the statistic of interest. Nevertheless, some estimate of the reliability of each statistic is desirable. A separate correlation was computed for each subject, which necessitated reanalysis of the same data in several instances. This nonindependence of the data created a problem when it came to significance testing. A conservative approach was employed, which treated the mean correlation as if it were the correlation of a single subject with all other subjects and used the appropriate significance test.

Table 2 shows the degree of association of the four affiliative categories with the five variables of interest. From the means it appears that the strongest influence on the direction of affiliative behaviors was companionship during the first 18 months of life ($r = +.29$), followed by rearing condition ($r = +.17$), patrilineal kinship ($r = +.16$), and shared kinship ($r = +.16$), with matrilineal kinship showing no relationship at all ($r = +.03$).

Since at least three variables appeared to be influencing the direction of affiliative behaviors in the monkeys, a true estimate of their relative strengths was desirable. As it was desirable to get an unbiased estimate of the relationship between affiliation and kinship, a statistical method of disentangling the variables was needed. The Kendall Partial Rank Order Correlation Coefficient was chosen. So the correlation of companionship with affiliative behaviors was calculated by partialling out the influence of both rearing condition and patrilineal kinship. Similarly, the correlation of rearing with affiliation was computed, partialling out any correlation due to companionship and patrilineal kinship. These values are given in parentheses in Table 2, which shows that both early companionship and early rearing influenced preference for the direction of affiliative behaviors.

In each column (1) of Table 3 are repeated the correlations of the confounded kinship measures with the four behavioral patterns. In each column (2) are the correlations of kinship with behavior, removing any influencing correlation due to rearing condition. It can be seen that when any association due to rearing was removed, there was little reduction in the correlation between kinship and affiliation. For patrilineal kinship the reduction averaged only just over .01. When partialling out the correlation due to companionship (columns 3), however, there was a greater reduction in the level of association.

**TABLE 2. Correlations between Five Variables with Each of Four Behavioral Patterns.**

<table>
<thead>
<tr>
<th>Behavioral Pattern</th>
<th>Companionship</th>
<th>Rearing Condition</th>
<th>Patrilineal Kinship</th>
<th>Matrilineal Kinship</th>
<th>Shared Kinship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity</td>
<td>.29*** (.22***)</td>
<td>.15** (.06)</td>
<td>.21***</td>
<td>.01</td>
<td>.19</td>
</tr>
<tr>
<td>Contact</td>
<td>.29*** (.23***)</td>
<td>.17** (.10*)</td>
<td>.16**</td>
<td>.06</td>
<td>.15</td>
</tr>
<tr>
<td>Groom</td>
<td>.26*** (.20***)</td>
<td>.20*** (.12*)</td>
<td>.12*</td>
<td>.02</td>
<td>.11</td>
</tr>
<tr>
<td>Play</td>
<td>.33*** (.28***)</td>
<td>.16** (.06)</td>
<td>.16**</td>
<td>.04</td>
<td>.14</td>
</tr>
<tr>
<td>Mean</td>
<td>.29 (.23)</td>
<td>.17 (.085)</td>
<td>.16</td>
<td>.03</td>
<td>.15</td>
</tr>
</tbody>
</table>

The coefficients in parentheses are those remaining when other variables are partialled out, as explained in the text; all correlations are positive.

* $p < .05$.

** $p < .01$.

*** $p < .001$. 
TABLE 3. Correlations of Three Kinship Variables with Each of Four Affiliative Behavioral Patterns: (1) = Kinship, Rearing and Companionship Confounded; (2) = (1) with Rearing Partialled Out; (3) = (1) with Companionship Partialled Out; (4) = (1) with Rearing and Companionship Partialled Out.

<table>
<thead>
<tr>
<th>Behavioral Pattern</th>
<th>Patrilineal Kinship</th>
<th>Matrilineal Kinship</th>
<th>Shared Kinship</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rearing</td>
<td>Companionship</td>
<td>Rearing &amp; Companionship</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Proximity</td>
<td>+.21***</td>
<td>+.21***</td>
<td>+.16**</td>
</tr>
<tr>
<td>Contact</td>
<td>+.16**</td>
<td>+.14**</td>
<td>+.10</td>
</tr>
<tr>
<td>Groom</td>
<td>+.12*</td>
<td>+.10*</td>
<td>+.07</td>
</tr>
<tr>
<td>Play</td>
<td>+16**</td>
<td>+1.4**</td>
<td>+.09</td>
</tr>
<tr>
<td>Mean</td>
<td>+.10</td>
<td></td>
<td>-.005</td>
</tr>
</tbody>
</table>

*p < .05.
**p < .01.
***p < .001.
between kinship and behavior, especially for patrilineal kinship, where there was substantial association to begin with (see column 1). Here, the reduction averages just under .06. This confirms that early companionship was the most important variable of those measured in influencing social preference among the monkeys.

Since both early rearing and early companionship have been shown to influence preference, a final series of three partial correlations was computed. In these correlations, any influences due to either rearing or companionship were statistically removed. The results in the columns marked (4) show that when both variables were partialled out, there was no substantial reduction in the correlation between behavior and kinship in comparison with that seen when simply removing the contribution to the correlation due to companionship alone (column 3). It can be seen that when one looks simply at the correlation of kinship with affiliative behavior, patrilineal kinship and shared kinship were influencing the pattern of all four affiliative behaviors (column 1), but matrilineal kinship was not. When partialling out the variance due to early companionship, it is only with patrilineally related kin and shared kin that individuals direct and receive more time in proximity than would be expected by chance.

If we average the partial correlation coefficients from the four behavioral categories (in Tables 2 and 3), we can simply summarize the relative contributions of the four variables studied. The correlation of affiliative behaviors with companionship was the strongest \((r = +.23)\), followed by shared kinship \((r = +.11)\), patrilineal kinship \((r = +.10)\), and early rearing condition \((r = +.085)\), with matrilineal kinship being by far the weakest \((r = -.005)\).

**Discussion**

It is not surprising that companionship shows the highest correlation with the measures of social preference. This is the norm for macaques, in which early companions are normally close kin, and fostering studies that control for kinship confirm the importance of familiarity (Chamove, unpublished data). In our study, of the six “mother”-reared monkeys, two had been placed with foster mothers soon after birth and their bonding was indistinguishable from the four raised by their natural mothers. One could argue that for the other 20 subjects, who were maternally deprived, attachments formed to companions who might have acted as maternal surrogates would be even stronger, in compensation.

The weakness of the correlation of social preferences with conditions of early rearing is at first glance surprising, given Pratt and Sackett’s (1967) clear results. However, they compared only three groups: totally deprived, partly deprived, and peer-raised. Thus, subjects had a choice of three relatively easily discernable alternatives. In our more complex study, early rearing was much more varied: 11 D monkeys had between them four types of upbringing, 9 P monkeys had five types of upbringing, and 6 M monkeys had two types of upbringing. Furthermore, some subjects had spent more of their first 10 months in a rearing regime than had others of the same type. Each of the 26 subjects, therefore, had a wide choice of partners whose backgrounds must have been difficult to discriminate.

The most surprising result was the marked difference in influence between patrilineal and matrilineal kinship. (The third category of kinship, in which dyads shared both patrilineal and matrilineal genes, was thus intermediate. Its few cases were predictably more or less equivalent to patrilineal genes in influence.) In effect, matrilineal genes made no detectable contribution to the social preferences recorded.
Until recently, such differential effects would have been considered startling, to say the least. [See, however, Kurland (1979) for a possible theoretical basis.] Primatologists have assumed that their subjects were unable to distinguish relatives through the father unless social cues were present. However, the results fit an emerging pattern. In Wu et al.'s (1980) study, the half-sibs who recognized one another were paternally related, i.e., had a common father but different mothers (but see Fredrickson & Sackett, 1984). In Small and Smith's (1981) study of rhesus macaques, mothers' resistance to the "grabbing" of their infants differed according to kinship. Paternal half-siblings of the infants were tolerated more than were nonrelatives. The effect is not limited to primates: Waldman (1981) showed that tadpoles of the American toad (Bufo americanus) raised in isolation showed later kin discrimination. They preferred to associate with paternal half-siblings rather than maternal half-siblings.

Why does such discrimination exist? We suggest that in species with maternal or matrilineal caretaking of offspring, recognition of matrilineal genes is accomplished de facto by the coincidence of familiarity and relatedness. Thus, in such species, maternally and matrilineally deprived individuals, such as most of our monkeys, would be at a loss to recognize those kin later in life. There is probably a high correlation between these two variables. Bekoff (1981) has gone so far as to talk of a "coefficient of familiarity," but we are aware of only one study that has tested this directly, in ground squirrels (Spermophilus beldingi) (Holmes & Sherman, 1983). Put another way, natural selection need not be so sharp for matrilineal kin recognition and discrimination, since it is normally taken care of by experiential factors.

On the other hand, patrilineal relatives may have no other means of recognizing kin in species in which fathers take no direct part in rearing offspring. Thus, those genes that enhanced innate abilities to recognize their replicates would be strongly selected for. This is the "genetic recognition mechanism" hypothesized by Hamilton (1964). The differences in parental caretaking give rise to some specifically testable hypotheses: Species that show more or less equivalent parental input into the rearing of offspring (i.e., Callithrix, marmosets and tamarins) should show little innate kin recognition and should not be able to distinguish matrilineal from patrilineal kin. Species that show solely maternal rearing, in which fathers and their relatives are rarely seen (e.g., Pongo pygmaeus, orangutan) should show the reverse.

How does such discrimination operate? Numerous authors have suggested that mothers (or matrilineal relatives?) somehow "label" the young. This may be done physically through any of the sensory modalities, e.g., Waldman (1981) suggests that toads do it chemoreceptively through the cytoplasmic constituents of the egg-jelly. Alternatively, this labeling may be done behaviorally. We are not aware of any conclusive demonstration of this, but it is implicitly suggested by some studies (e.g., Walters, 1981). When recognition is achieved through patrilineal genes, it is hard to see how behavioral cues could be involved, if fathers do not take part in rearing. This suggests some form of learning to match phenotypic characteristics (Alexander & Borgia, 1978). The physical cues can be elucidated through careful experimental design: Bateson (1983) has shown that for Japanese quail (Coturnix coturnix), a scorable set of characteristics, mostly in the plumage, co-varies with the degree of relatedness, thus providing a basis for visual discrimination. For primates, the sensory modalities involved remain to be shown; in our study it could have been one or more of any of the senses.

In summary, early companionship, rearing conditions, and kinship all contribute to social preferences in later life. In our abnormal and heterogeneous group, each component effect was weak but statistically significant and additive, and this could be taken to indicate the likely robustness of the phenomenon under more normal conditions.
Notes

The authors thank J. Anderson and V. Nash for advice in computer analysis, T. Tanner and I. Rodgerson for assistance, especially in learning to recognize the monkeys, R. Macdonald for statistical help, and A. Collins for critical comments on the manuscript.

References


Early Social Experience and Responses to Visual Social Stimuli in Young Monkeys

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University of Stirling

Juvenile stump-tailed macaques (Macaca arctoides) were given preference tests in which they could approach an empty chamber, a mirror, a familiar conspecific, or an unfamiliar conspecific. Control subjects tended to withdraw from the mirror, and threatened the stranger more than did monkeys whose early social experience had occurred exclusively in darkness. Both groups explored the familiar stimulus animal most of all, but the group socialized in the dark showed most positive behavior when in the empty chamber. In a second study peer-reared infants responded more appropriately to slides of conspecifics than did infants reared with a mirror as the main source of social input. Infants reared only with a peer were also strongly attracted to a mirror, whereas infants reared only with mirrors preferred a film of an unfamiliar age-mate. The results suggest that early visual social stimulation is important in the development of aggression and other social behaviors, and that novelty and complexity are important aspects of social stimuli that interact with effects of early experience.

There is strong evidence for genetically based sensitivities and social experience interacting to shape responsiveness to visual social stimuli in primates. Sackett (1966) showed that during early isolation rhesus monkeys (Macaca mulatta) were more responsive to projected pictures of infant monkeys and monkey threats than to other slides of monkeys or inanimate scenes. Between 2 and 4 months of age, disturbance behaviors and vocalization peaked when pictures of threats were shown. Between 4 and 7 months disturbance in response to the threat pictures declined, but remained higher than with other slides. These findings were interpreted as evidence of predispositions toward responding to particular classes of stimuli, and as evidence of the visual threat stimulus acting as an “innate releasing stimulus” akin to sign stimuli identified in other animals.

Pictorial stimuli have been used in other studies of monkeys’ reactions to stimuli differing in emotional content. Using an operant paradigm with socially reared rhesus juveniles, Redican et al. (1971) found that the monkeys varied their response rates according to facial expressions depicted only on faces of juveniles. Subjects responded less for pictures of threat and grimace than for lipsmack, yawn, or plain faces. These results suggested that (1) macaques may dislike pictures of negative affect (e.g. grimace) rather than having a specific aversion to threats, and (2) monkeys may be particularly responsive to pictures of age-mates rather than to pictures of infants (cf. Sackett, 1966)
Early social experience affects responsiveness to visual social stimuli. Socially reared rhesus macaques looked longer at slides of conspecifics than at nonmonkey slides, whereas isolation-reared subjects looked longer at slides of inanimate scenes or a human than at most of the monkey slides (Sackett, 1965).

Although several types of visual social stimulation have been used in studies of the effects of rearing conditions on adaptation—e.g., live animals behind transparent partitions (Chamove & Harlow, 1975), televised pictures (Miller et al., 1967), films (Fittinghoff et al., 1974), and mirror-image stimulation (MIS) (Gallup & McClure, 1971)—pictures of conspecifics have been only rarely used in studies of behavioral development and effects of early rearing conditions in monkeys. This seems surprising given the strong response-eliciting properties of projected pictures and the good possibility of stimulus control.

Complexity and novelty are recognized as important determinants of stimuli influencing how subjects respond to them (e.g., Sackett, 1973), but such stimulus features are not often considered when adaptation to social stimuli is discussed. In the experiments reported in this article, we used various visual social stimuli: live familiar and unfamiliar conspecifics, slides, a film, and a mirror to examine responsiveness in differentially reared stumptailed macaques. Specifically it will be shown that (1) manipulating the amount of early visual social experience affects later responses to visual social stimuli, and (2) that systematic comparisons of the psychological properties of various social stimuli is a useful technique in the study of social perception in primates.

STUDY 1

In this study juvenile macaques were given preference tests aimed at determining (1) whether different rearing conditions resulted in preferences for particular types of social stimulation, and (2) whether early social visual restriction affected responses to classes of social stimuli that varied in an intuitive assessment of complexity and novelty.

METHOD

Subjects and Rearing Conditions

Eight stumptailed macaques (Macaca arctoides) had been separated from their mothers in the first week of life and raised in individual cages with no visual access to other monkeys, although they could see masked humans (see Chamove, 1981, for details). Each monkey had a diaper in its cage. Beginning at 2 months of age they were given social experience of between 1.5 and 4 hours daily, in a large cage in which they were later to be tested (see below). The control group (1 male, 3 females) was socialized in pairs using all combinations of partners within the group, and intermittently in tours. Half of these socialization sessions occurred under normal room illumination, but on alternate days the monkeys interacted in total darkness.
The experimental "dark" group (also 1 male, 3 females) received identical social experience, except that it all occurred in total darkness.

All socialization sessions were monitored via a television camera, under infrared lighting when necessary. Otherwise, housing was in normal lighting conditions. These rearing conditions lasted until the subjects were 21 months old. Just before the present experiment began, both groups underwent 10 days of alternating light and dark socialization sessions.

Procedure

The eight subjects were tested individually in a large, wedge-shaped cage 85 cm wide at the narrow end, broadening to 280 cm at the opposite end. It was 198.5 cm long and 140 cm high, with the floor 55 cm above the floor of the room. The cage was divided into a central area and four choice compartments. From the central area the subjects could see into the four compartments, but they could not see from one compartment into another due to the opaque dividing walls. The end wall of each choice compartment was transparent.

Each subject was placed into the central area of the test cage and lett for 10 minutes to adapt. During this period a white opaque screen placed across the entrance to the four choice compartments prevented the subject from seeing into them. Observations began immediately after the screen was removed and the subject was free to enter the compartments. The extreme right compartment contained a 22 × 25 cm mirror directly behind the transparent end wall. The leftmost compartment was empty, and the middle two compartments contained stimulus animals in transport boxes with a transparent front against the transparent end wall. The preference test was the subjects' first experience of a mirror or a conspecific outside their own group. One stimulus animal was from the subject's own group, and the other was unfamiliar, being from the other group. Each subject had three such tests using different stimulus animals in each case. The initial assignment of stimuli to the choice chambers was decided randomly.

During each 15-minute test the following behaviors were recorded as occurring or not occurring in 10-second intervals signalled by the metronome: approach, noncontact aggression, contact and noncontact exploration, play, affiliation, and withdrawal. Contact was recorded when the subject contacted the transparent end wall. In addition, behaviors were recorded as being directed toward the stimuli (i.e., live animal, mirror, or end wall of the empty compartment, or elsewhere).

Two analyses of variance were used to assess the data. They both used group as a between subjects variable, and repeated measures included both the stimulus conditions and the two degrees of contact. The first analysis examined negative behaviors as repeated measures (i.e., withdrawal, noncontact aggression, and contact aggression). The second used four positive behaviors as repeated measures (i.e., approach, noncontact explore, contact explore, and play). Affiliation was not analyzed because of its infrequent occurrence. Using behaviors as a repeated measure enabled the number of analyses to be kept low and thereby helped to conserve alpha.
RESULTS

The analysis of the three negative behaviors showed a significant highest order interaction, $F(2, 12)=6.34, p<.05$. As shown in Figure 1, the control subjects showed more withdrawal than the dark subjects, especially from the mirror, but did not withdraw differentially from the two live stimulus animals. The dark group did not withdraw differentially from the three stimuli. Aggression to the mirror was infrequent. The control group displayed the most aggression toward the stranger, and showed mainly noncontact aggression. In contrast almost all of the dark group's aggression involved contact, and it was directed approximately equally toward the familiar and unfamiliar stimulus animals (LSD=4.0).

The analysis of the positive behaviors resulted in two significant interactions with group: group $\times$ behavior, $F(1, 6)=15.93, p<.01$; and group $\times$ behavior $\times$ direction, $F(1, 6)=6.0, p<.05$. The latter indicated that the dark subjects responded more positively when in the empty chamber than the controls. Indeed the dark subjects exhibited more positive behaviors when in the empty chamber than when in the sections with the mirror or either stimulus animal. In decreasing order the control
group exhibited most positive responses toward the familiar stimulus monkey, the stranger, the mirror, and the empty chamber.

The group × behavior interaction showed that a greater proportion of the control group’s behavior consisted of contact exploration compared to the dark group, and the former group showed the greater proportion of environmentally directed non-contact exploration.

In the analysis of positive behaviors there was also a highly significant interaction of behavior with stimulus. \( F(3, 18) = 28.7, p < .001 \) (see Figure 2). It showed that in both groups exploration was most commonly directed toward the familiar stimulus animal and that the mirror received less exploration of both types than either of the live stimulus animals (LSD = 2.2). Although not part of a significant interaction, the control group showed 2.7 times and 1.3 times as much noncontact and contact exploration toward the mirror as the dark group.

In summary, the animals without visual social experience until juvenile age showed less aggression toward a stranger, especially noncontact aggression, and less withdrawal, especially from abnormal social stimuli such as MIS, than did visually socially experienced subjects. They also exhibited less positive behavior toward the stimuli, preferring the simple empty chamber to those containing the more complex stranger or a mirror. whereas control subjects preferred the more complex stranger or a mirror over an empty chamber.

STUDY 2

Study 2 examined effects of long-term rearing with an “abnormal” (mirror image) companion on responses to visual social stimuli varying in novelty, complexity, and emotional content.

METHOD

Subjects and Rearing Conditions

The subjects were eight infant stumptails serving as subjects in a longitudinal study on self-recognition and behavioral development (Anderson, 1981). They had the same experience as the above-mentioned monkeys until the age of 2 months. At that time four of them (3 males, 1 female) formed the “peer-reared” group, consisting of two pairs. The peer-only (PO) pair was a subgroup of the above and lived together continuously from Monday morning until Friday morning, but were housed individually Friday-Monday. The peer-mirror (PM) pair was another subgroup reared identically except that Friday-Monday they were each housed with two full-length mirrors in their cages. The “mirror-reared” group, (2 males, 2 females) also consisted of two pairs. The two mirror-only (MO) subjects each lived with mirrors in their cages Monday-Friday, and without mirrors Friday-Monday. The two mirror-perspex (MX) monkeys also had mirrors in their individual weekday cages. They had no mirrors over the weekend, but they had an unobstructed view into each other’s cage through transparent walls of the cages.
The behavior of all of the subjects was recorded every day. Beginning at 7 months of age they were given tests employing novel environments and social stimuli. They had all had a maximum of a few minutes exposure to slides and to a mirror in the test cage (see below), to which they were accustomed. At the time of the present tests they averaged approximately 10 months of age, and continued to live in their experimental rearing conditions.

Procedure

The tests were conducted using only the rightmost choice compartment of the experimental cage. The first test ("slide test") assessed the subjects' responses to pro-

FIGURE 2
Stimulus- plus environment-directed positive behaviors during the preference test

![Graph showing positive behaviors during the preference test]
jected pictures of conspecifics. Two sets of five slides were presented to each subject, one set in each session. Each slide gave a color, frontal view of a stumptailed macaque. Slides of adults showed the head and part of the upper torso; slides of infants showed the entire length of the body. The projected images were approximately life size. Each set of slides contained one example of the following: infant explore, infant fear, adult female explore, adult female fear, and adult male threat.

To begin a slide test, the subject was placed into the test cage, and the projector was switched on to illuminate the screen. After about 30 seconds the first picture was projected, at a moment when the subject was facing away from the screen. The subject’s responses were recorded for 3 minutes, after which the projector was switched off. The next trial started 2 minutes later, following the same procedure. Session 2, using the second set of five slides, occurred the following day. In both sessions the order of presentation of the slides was random.

The second test (“film and mirror test”) assessed responses to a film of a conspecific and to MIS. It was conducted 4 days after the second slide test session. In between, the subjects were given two trials in which they could choose to approach the film or the mirror, but these trials are not reported here. These unreported choice trials constituted the first experience of MIS for the two PO subjects: a possible maximum of 14 minutes, but in reality much less.

The procedure for the film and mirror exposure test was very similar to that for the slide test. Each subject received four 3-minute trials, two with the film of an infant stumptail and two with a mirror. The first stimulus for each subject was decided randomly, and thereafter consecutive trials involved the alternative stimulus. The film showed a 7-month infant in a transparent cage, mostly walking and manipulating or holding its diaper, and sometimes sucking its thumb. There was no soundtrack. The image of the infant monkey was approximately lifesize. The film lasted 4 minutes and 30 seconds, meaning that there was some overlap in the material projected in the two film trials. The mirror measured 22 × 25 cm. The paper screen onto which the film was back-projected was removed immediately before the mirror was positioned for the start of a mirror trial.

In both tests the following behaviors were recorded: submission, exploration, play, aggression, and affiliation, with information as to whether the subject contacted the transparent partition in front of the stimulus also recorded (definitions as in Anderson, 1981). Data were collected using a 9-key keyboard linked to a “Data Transfer Unit,” which transferred records of sequences of key presses onto paper tape for later computer analysis.

The slide test data were analyzed in analyses of variance with group (mirror-reared or peer-reared) as the between subjects variable, and session (1 or 2), age of stimulus animal (infant or adult), expression of stimulus animal (neutral or fear), and form (contact or not) as repeated measures. The adult male threat trials were analyzed separately.

The film and mirror test data were also analyzed in analyses of variance, but because of the unequal distribution of early experience of mirrors, two between subjects variables were used. One was group, as before. The second was whether the
subjects had any social experience in addition to their primary rearing partner. MO and PO subjects had none, whereas MX and PM subjects both experienced two types of social partner during rearing.

In all analyses, alpha was set at .05, and significant effects were further analyzed using the method of the Least Significant Difference (LSD).

RESULTS

Slide Tests

In the slide tests there was too little submission, aggression, or play to reveal any reliable effects, although peer-reared monkeys tended to be more submissive toward the threat slides than were mirror-reared monkeys.

The monkeys explored pictures of infants reliably more frequently than pictures of adult females. $F(1, 6) = 7.1, p < .05$, but not for longer (18% and 15% of test time, respectively). Expression $\times$ form in the rate analysis, $F(1, 6) = 8.4, p < .05$, indicated a greater difference between rate of noncontact exploration and contact exploration of fear faces (means 25.6 and 4.8 per 5 minutes, respectively) than of neutral faces (23.7 and 6.0). Also significant was group $\times$ session $\times$ form, $F(1, 6) = 17.8, p < .01$. Table 1 presents all of the means. Whereas exploration rates remained fairly stable across sessions in mirror-reared monkeys, peer-reared monkeys increased their rate of contact exploration of the slides by around 50% in Session 2, and decreased their rate of noncontact exploration. This produced differences between the groups in Session 2 (LSD = 3.2).

Table 1 also shows that in both groups contact exploration of the adult male threat increased from Session 1 to Session 2, at the expense of noncontact exploration, $F(1, 6) = 6.5, p < .05$. In the rate analysis the group $\times$ age $\times$ form interaction was also significant, $F(1, 6) = 12.0, p < .05$. Neither group contacted slides of infants and adult females at different rates, but they both looked at infant slides more frequently (LSD = 1.0). Peer-reared subjects contacted both types of slides more often than did

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Scores for Exploration of Color Slides by Two Groups of Infants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Behavior</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Mirror-reared</td>
<td>Contact</td>
</tr>
<tr>
<td></td>
<td>% time</td>
</tr>
<tr>
<td></td>
<td>Noncontact</td>
</tr>
<tr>
<td></td>
<td>% time</td>
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<tr>
<td>Peer-reared</td>
<td>Contact</td>
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<tr>
<td></td>
<td>% time</td>
</tr>
<tr>
<td></td>
<td>Noncontact</td>
</tr>
<tr>
<td></td>
<td>% time</td>
</tr>
</tbody>
</table>
mirror-reared subjects, while the latter group engaged in relatively more looking at infant slides. It can also be seen in Table 1 that peer-reared subjects appeared to look at the threats more frequently than did mirror-reared subjects, but the differences were not significant.

Several more effects emerged in analyzing the percentage of time in exploration of the stimulus, including the highest order interaction, $F(1, 6)=7.0, p<.05$. Only peer-reared animals reliably increased time in contact with the slides in Session 2; their noncontact scores did not vary. Mirror-reared subjects, on the other hand, strongly increased the time spent looking at the infant slides in Session 2, and decreased attention to the adult female slides. Peer-reared subjects exceeded their mirror-reared counterparts in contacting the adult female pictures in both sessions and infant pictures in Session 2, but the reverse relationship was obtained for noncontact exploration of infant slides in Session 2. Table 1 also shows that, in general, contact exploration of the threat pictures was lower than that with the other slides.

Affiliative responses were quite rare, but they revealed differences between the groups. Affiliation was three times more frequent in the peer-reared group (rates of 0.6 and 1.9). Group × session × expression was significant, $F(1, 6)=8.7, p<.05$, showing that mirror-reared subjects increased the rate of affiliation toward both neutral and fear slides in Session 2, but they did not respond differentially toward the two types of slide. Peer-reared subjects, on the other hand, were less frequently affiliative to neutral slides in the second session, but were more affiliative to slides depicting fear. Peer-reared monkeys were more affiliative to fear slides than were mirror-reared monkeys, and the same relationship held for neutral slides in Session 1.

Peer-reared subjects also appeared more affiliative toward the adult male threats, but this effect was not significant, nor was the decrease in rate of affiliation to the threat in Session 2. In neither group did the threat stimuli elicit strikingly high rates of affiliation.

Peer-reared animals exhibited affiliation 0.8% of the time, mirror-reared animals 0.3% of the time, $F(1, 6)=6.8, p<.05$. In the group × session × age × form interaction, $F(1, 6)=6.4, p<.05$, only one difference between sessions was notable, namely an increase in noncontact affiliation toward infant slides by mirror-reared subjects. Contact affiliation with infant slides was more likely in peer-reared than mirror-reared monkeys, but only significantly so in Session 2, whereas the same was true toward adult female pictures in Session 1.

In summary, the peer-reared group appeared most sensitive to the content of the slides. For example, they all exhibited submission to the adult male threat slide, whereas only one mirror-reared subject did so, and their affiliative responses to neutral and fear slides changed over sessions whereas those of mirror-reared subjects did not. The peer-reared subjects also lipsmacked (noncontact affiliation) more frequently to the adult male threats, and this reaction did not occur in the mirror-reared group during the second presentation. Peer-reared subjects were more likely to engage in contact affiliation with the slides. Overall, pictures of infant monkeys attracted more frequent looks than did pictures of adult females. Noncontact explora-
tion was more frequent and contact exploration less frequent when fear faces, rather than neutral expressions, were presented. The latter behavior was more common in the peer-reared group than in the mirror-reared group, especially in the second session. whereas mirror-reared subjects were the most frequent lookers at slides of infants. Both groups of subjects were reluctant to contact the adult male threat slides, especially in Session 1. In Session 2, contact exploration increased, at the expense of simple looking. Only the peer-reared group gave an indication of spending more time in visual exploration of the adult male threat than the other categories of slides.

**Film and Mirror Test**

Exploration of the stimuli was 30% more frequent in mirror-reared animals than in peer-reared animals (means 48.8 and 36.9, respectively). $F(1, 4)=10.5, p<.05$, and the same result emerged in the duration analysis (24% versus 18%), $F(1, 4)=20.4, p<.05$. Overall, the mirror commanded more frequent exploration than the film, with visual exploration predominating. Exploration increased during the second presentation, this effect being mainly due to contact exploration. $F(1, 4)=15.4, p<.05$.

In both rate and duration analyses of exploration, group × additional experience × stimulus was significant. $F(1, 4)=10.2, p<.05$ (rate); $F(1, 4)=21.2, p<.05$ (duration). Figure 3 illustrates these effects. Both mirror-reared pairs explored the film more frequently than did the peer-reared pairs. PO animals explored the mirror more frequently than the film. There were no within-group differences in rate of exploration. In terms of the amount of time spent exploring the stimuli, MO animals clearly exceeded all other pairs in exploring the film. 32% of time versus less than 15% of time in the two peer-reared pairs (LSD=6.0). Furthermore, MO pair’s film exploration score was reliably higher than its mirror exploration score, while the MX pair did not differentially explore the two stimuli. Of the two peer-reared pairs, only the PO pair differentially explored the film and mirror, the latter stimulus eliciting over 50% more exploration. Analysis of the length of noncontact exploration bouts revealed no significant effects. Analysis of the time spent in affiliation with the stimuli gave one reliable result: affiliation toward the mirror was over 7 times more common than toward the film, 4.9% and 0.7%, respectively. $F(1, 4)=11.9, p<.05$. The rate of affiliative responses was also 15 times higher than to the film, $F(1, 4)=13.2, p<.05$.

---

**TABLE 2**

Rates of Affiliative Responses Toward a Film and a Mirror Over Two Presentations

<table>
<thead>
<tr>
<th>Pair</th>
<th>1 Film</th>
<th>2 Film</th>
<th>1 Mirror</th>
<th>2 Mirror</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirror-Only</td>
<td>2.1</td>
<td>0.0</td>
<td>4.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Mirror-Perspex</td>
<td>0.0</td>
<td>1.7</td>
<td>12.6</td>
<td>8.3</td>
</tr>
<tr>
<td>Peer-Only</td>
<td>0.0</td>
<td>0.0</td>
<td>14.3</td>
<td>6.8</td>
</tr>
<tr>
<td>Peer-Mirror</td>
<td>0.0</td>
<td>0.0</td>
<td>4.2</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Anderson and Chamove
Two notable interactions in the rate analysis were group $\times$ additional experience $\times$ stimulus $\times$ form ($p = .054$), and the highest order interaction ($p = .055$). Table 2 presents the means, omitting the form variable. In all pairs affiliation toward the film was infrequent. The first presentation of the mirror was associated with considerably more affiliative responses, especially in PO and MX animals. The second mirror presentation resulted in lower affiliation scores in all but the PM pair. Neither stimulus elicited much agonistic behavior or play, although the latter was 5 times more frequent toward the mirror than the film (not significant).
In summary, the mirror was a more potent stimulus than the film of a like-aged infant. The mirror-reared animals, especially those whose entire social experience consisted of MIS (MO pair), were particularly attentive to the film, whereas animals reared only with a peer (PO pair) were highly exploratory toward the mirror. The latter subjects also produced the highest mirror-directed affiliation score of all.

**DISCUSSION**

In the preference test in Study 1, monkeys given social experience during infancy both in the light and in darkness responded more positively toward a familiar stimulus monkey than toward a stranger or their own mirror images. This is in agreement with the earlier findings of monkeys preferring to approach stimulus animals with similar social histories (Pratt & Sackett, 1967), although a role of familiarity per se cannot be ruled out in the present experiment.

To the control monkeys the mirror image and the unfamiliar stimulus monkey presented a choice between unknown categories of conspecifics. These subjects withdrew more from the mirror but threatened the live stranger, suggesting avoidance of the "abnormal" animal in the mirror by socially sophisticated animals (see also Anderson, 1983). The data also confirm that approach might be correlated with aggression as well as affiliation (e.g., Mitchell, 1972).

The dark group, limited in visual social experience, spent most time in the empty chamber, somewhat reminiscent of isolation-reared rhesus (Sackett, 1973). They showed little noncontact aggression, however, reinforcing the view that the normal development of visual threat in macaques depends upon experience of visual social stimuli in early life (Chamove, 1978). The dark group also explored the familiar stimulus monkey more than the other social stimuli, but unlike controls they did not withdraw from the mirror more than from the live stimulus animals, further suggesting that visually socially restricted monkeys are less fearful of stimuli such as MIS than are more sophisticated monkeys (see Anderson, 1983; Gallup & McClure, 1971; Spencer-Booth & Hinde, 1969).

In Study 2, infant monkeys explored pictures of conspecifics profusely, but other social responses were rare. There were behavioral differences between animals from different rearing conditions during the slide tests, recalling those reported by Sackett (1963) for adult rhesus, and by Sackett (1972) and Wood et al. (1979) who used slides depicting material other than conspecifics. On the whole, the peer-reared group appeared to respond more appropriately to the content of the slides: they were the more likely to look longer and to lipsmack to the adult male threat picture, and to initiate contact and affiliation with other slides.

Clearly, the content of the slides was also an important factor in how the monkeys responded, extending to stumptailed infants effects observed in rhesus infants (Sackett, 1966), and juveniles (Hau de & Detwiler, 1976, Redican et al., 1971). The present subjects appeared more attentive to pictures of infants than to pictures of adult females, indicating that novel exemplars of the category "infant," which all subjects knew, were more attractive than exemplars of a completely novel category.
Two infant stumptails reared entirely alone and tested with the same slides were also most responsive to slides of infants (unpublished data), which strengthens the case for innate attraction to agemates in infant macaques.

The comparison of reactions to MIS with those to a moving film of a conspecific was interesting because the latter represented a conspecific whose behavior was entirely out of synchrony with the subject's actions. In general, the mirror stimulus elicited stronger reactions than did the color film. Mirror-only-reared monkeys, for whom the film was the first experience of a moving monkey other than their own mirror images, were the only subjects to explore the novel film more than the mirror. The other subjects, experienced with moving peers, tended to explore the mirror more, but the difference only reached significance in the mirror-naive, peer-only pair. For these infants the irrelevant actions of the conspecific in the film appeared less compelling than the continuously reciprocating conspecific in the mirror. Interestingly, Meliska et al. (1980) reported a similar finding with Siamese fighting fish (Betta splendens). In contrast to PO subjects, MO subjects found the novelty of the independent movement by the animal in the film to be more interesting than the mirror image, with which they were experienced.

With only two subjects representing the rearing conditions in the film-mirror test, caution is required in interpreting the results. Taken with the other findings, however, they affirm the responsiveness of infant and juvenile macaques to still and moving color pictures of conspecifics, and to social stimulation in the form of a mirror. The results also indicate that infants are strongly attracted to pictures of infants, and that the image of an adult male threatening is aversive even to 10-month-old infants that have never seen an adult male. Visually socially experienced monkeys prefer their own kind over strangers or their own reflection, and show more noncontact aggression than visually inexperienced monkeys. In some cases, however, "simple" social stimuli such as MIS are more attractive than real conspecifics. Systematic investigations of the features of social stimulus configurations, combined with assessment of effects of varying social experiences, promise to throw further light on mechanisms of social perception in monkeys.

NOTE

Study 2 was conducted while the first author was in receipt of a Postgraduate Research Studentship from the U.K. Science Research Council. The DTU tapes were analyzed using a computer program developed with the help of SRC grant B/RG 989/10 to A. Chamove. This latter grant also supported the study from which the preference test data were taken. Technical assistance from J. Low is gratefully acknowledged. Date of acceptance for publication: October 25, 1983. First author's address: James R. Anderson, Psychology Primate Unit, University of Stirling, Stirling FK9 4LA, Scotland, U.K.

REFERENCES


Visitors Excite Primates in Zoos

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Fifteen species of primate were observed to assess the effects of zoo visitors on their social behavior. When visitors were present primates were less affiliative, more active, but more aggressive. These changes were particularly marked in arboreal monkeys, especially in smaller species, and were reduced by 50% by lowering the height of spectators. Detailed observations of a group of mandrills indicated that with increasing numbers of visitors the monkeys showed a linear increase in attention to visitors, in activity, and in stereotyped behavior. All of these effects are consistent with an interpretation that visitors are a source of stressful excitement rather than of enrichment.

Key words: monkeys, environment, stress, enrichment

INTRODUCTION

There has been considerable recent interest in improving captive environments and much of the research has centered on zoo environments [e.g., Chamove et al., 1982; Erwin and Deni, 1979]. Most of these studies have involved the addition of devices [Dathe, 1981; Markowitz, 1982; McKenzie et al., 1986] or material [Chamove and Anderson, 1979, 1988] which increase the complexity of a simple enclosure. There is, however, one category of stimulus which is a) variable in intensity over time, b) variable in its characteristics, but c) possibly stressful. That stimulus is the presence of strangers. It is possible that visitors present animals with just enough stimulation to enrich a stimulus-poor environment [Morris, 1964]. On the other hand, the presence of visitors may lead to an increase in the levels of stress above that which would be in the best interests of the animals.

There have been very few published studies designed to assess the effects of zoo visitors on primate behavior. One using the cotton-top tamarin [Glatston et al., 1984] suggested that the presence of visitors decreased the time the monkeys interacted socially; in particular, the monkeys were less amicable, they spent less time in contact with one another and played less, and were more agonistic. The duration but
not the frequency of several of these behaviors was altered by visitors. Although the confounding of observer, cage size, and contact with other groups makes any conclusions tentative, the authors also reported their “impression” that when on display, the monkeys were more inactive (“apathetic”).

A recent study of several primate species found that active visitors increased the animals’ activity and their interaction with visitors [Hosey and Druck, 1987].

We could find only three unpublished reports on visitor effects on behavior. An abstract of a paper [Maki et al., 1987] reports that exposure to unfamiliar humans increased intragroup aggression in chimpanzees, although the increase appeared to be largely (78%) limited to 20% of the individuals (all males) of the two groups assessed. Moreover, an unpublished study by Lahm [1981] on six species of primate, but concentrating on the spider monkey, seemed to suggest that increasing visitor density increased general activity and social behavior, but when visitor harassment was high, social behavior and especially affiliative behavior were decreased by about half. A third study of three primate species reported reductions of up to 50% in amicable behavior, increases in aggression of up to 600%, and increases in locomotion of up to 300% when visitors were in front of the cages [Worsley-White, 1988].

The present study assessed the effects zoo visitors have on the social behavior of 15 different primate species. First we looked at primates which vary in size and arboreality; then we tried to manipulate the visitor effect; and finally we looked in more detail at one particular group of mandrills.

STUDY 1

Methods

Three species of primate in three stable family groups were selected: a) A group of three cotton-top tamarins (Saguinus oedipus) was composed of an adult pair and one young independent male offspring. These monkeys are small (average body weight of adults is about 0.4 kg) and arboreal. b) A group of five Diana monkeys (Cercopithecus diana) consisted of an adult male, two adult females, and two young of different sexes. The youngest was 2 years old. These are arboreal monkeys with a medium body size (average body weight of adults about 5.0 kg). c) A group of four ring-tailed lemurs (Lemur catta) was made up of two adults and two young of different sexes, the youngest aged 1 year. These are terrestrial primates with a medium body size (average body weight of adults about 2.1 kg).

All animals were housed in the Edinburgh Zoological Gardens and were in enclosures with both indoor and outdoor compartments. The inside enclosures varied but were at least $5 \times 5.3 \times 4$ m and were furnished with ledges and dead trees. There was a thick glass window next to the indoor enclosures, which markedly reduced the amount of visitor noise reaching the animals.

All the animals were observed under two conditions: a) when there were at least six visitors present and b) when there were no visitors present. Testing for the different groups and for the two conditions was carried out at the same time of day, and this was either at 1000, 1200, or 1400 hours. Each animal was observed for two 10-min periods separated by 2 weeks for each visitor condition during the months of December and again in May, for a total of 40 min.

“Visitors present” was defined as a continuous 30-sec period when there were at least six people at the indoor viewing window. This number of people was sufficient to fill the window. “Visitors absent” was a 30-sec period when there was no one at the viewing window. The observer sat well away from the animal’s enclosure.
Four behavior categories were recorded at 10-sec intervals: agonistic behavior—any biting, hitting, threats, submission, or avoidance; grooming—social and self-grooming; affiliation—huddling, sitting within arm’s reach, and all positive social behavior other than grooming; inactivity—recorded whenever animals were not moving and were not engaged in any of the above behavior.

An analysis of variance (ANOVA) was used to evaluate differences between groups and between visitor conditions, and was done for each of the four behavior categories; the same form was used for each: species (3) \times vis\itors (2) \times time of day (3).

Results

The presence of zoo visitors was associated with a significant increase in aggression and a significant decrease in the other behavior categories measured. Specifically there was an increase in the level of agonistic behavior when visitors were at the viewing window (by a factor of over 5); a percentage decrease in grooming of 80\%, in inactivity of 55\%, and in affiliative behavior of 40\% in comparison with that of no-visitor levels. These changes are illustrated in Figure 1.

The stability of the change in agonistic behavior was confirmed by a significant visitors effect, $F = 34.6; df = 1,9; P = 0.0002$, which did not differ between species. The effect of visitors on grooming was also stable, showing a significant visitors effect, $F = 529.8; P < 0.0001$. The visitors were also associated with an altered level of inactivity, $F = 54.1; P < 0.0001$; but this showed an interaction with species, $F = 7.0; df = 2,9; P = 0.02$, suggesting that the ability of visitors to reduce inactivity was not the same in the three species. From Figure 1 it appears that the influence was less for the larger-sized arboreal Diana monkeys. The effect on affiliative behavior showed a similar pattern: a significant overall effect of visitors, $F = 69.4, P < 0.0001$, and a significant interaction of visitors with species, $F = 25.6, P = 0.0002$. Figure 1 shows how the reduction in affiliative behavior was only found in the arboreal tamarin and Diana groups, and not in the terrestrial lemurs.

It is encouraging that both the changes in and the absolute levels of agonistic, grooming, and affiliative behavior in our tamarins was comparable to that found in the study by Glatston et al. [1984].

STUDY 2

It was reasonable to infer from the results of the above-described study that visitors were causing behavioral changes in the animals which were consistent with an interpretation of stress. While zoos would be resistant to a reduction in the number of visitors, alternative methods of reducing stress could be assessed. Since visitor-related stress appeared greater in smaller and more arboreal animals, changing visitors to make them “smaller” and less “arboreal” seemed worthy of trial.

Several (eight) groups of volunteers were used when they approached the experimenter asking if they could help. If the group was over five in number, they were asked to approach the viewing window and watch for at least 5 min either a) standing as tall as possible, or b) crouched so that only their head was above the base of the window, that is just above 0.74 m from the ground. An attempt was made to balance the order of the two conditions. Individual animals were observed for 1 min each, with the same behavior recorded at 5-sec intervals. Also noted were the number of “glances” the focal animal made towards the viewing window; this latter behavior was noted whenever it occurred.
Fig. 1. Levels of four behaviors (frequency at 10-sec intervals) when visitors were absent (clear) and when present (stipple). The circles show levels of behavior when visitors were crouching with only their heads visible to the animals (study 2).

Results

The effect of visitors' crouching was a reduction in stress as shown by a significant difference between the two visitor conditions for grooming, inactivity, and agonistic behavior although not for affiliative behavior. Respective ANOVA results were as follows: F = 72.1; df = 1,9; P < 0.0001; F = 31.9; P = 0.002; F = 35.0; P = 0.002; F = 9.5, P = 0.02. There was less inactivity, less grooming, and more agonistic behavior when the visitors were fully visible than when only their heads were visible and their heads were at a lower angle. The effects were strongest for the small arboreal tamarins, less strong for the larger arboreal Diana monkeys, and weakest for the terrestrial lemurs; but it must be noted that the effects were present for all three species, as shown by a significant interaction with species for the analysis of inactivity, F = 25.2; df = 2,9; P = 0.0002.
As the behavior of the monkeys in the presence of standing visitors did not significantly differ from that shown in the visitor condition of study 1, the data were combined for analysis and are combined in Figure 1.

The analysis of glancing at the visitors confirmed the above ordering. The tamarins looked the most and the lemurs the least, glancing in the direction of the visitors only 25% of that of the former (see also Thomson, 1974).

When comparing behavior of the animals in the presence of “smaller” crouching visitors with the no-visitor condition, the change in the animals’ behavior associated with the presence of crouching visitors was reduced by about half from that in the presence of taller visitors. The drop in the level of grooming was only about 30% (versus 80% for the comparison in study 1); the drop in inactivity was 25% (versus 55%); affiliation was reduced by 25% (versus 40%); and agonistic behavior increased by a factor of only 2 (versus 5). The levels of behavior when visitors were crouching is indicated in Figure 1 by open circles.

Discussion

Certainly the stimulation presented by visitors was associated with changes in certain behavior in the primates studies. It appeared that visitors excited the animals so that they a) were more active and less inactive, b) directed less amicable/affiliative behavior towards one another, and c) were more socially aggressive. This pattern of behavior change suggests that the stimulation caused by visitors is an irritable one, in that it leads to similar patterns of behavior change (e.g., increases in aggression) as commonly found with types of stimulation characterized as frustrating, threatening, or competitive [Baer, 1971; Chamove et al., 1984; Cooper and Markowitz, 1979; Mather, 1981]. It further suggests that visitor stimulation is unlike that of forms of positive stimulation or enrichment, such as tasks which generally lead to reductions in aggression [Anderson and Chamove, 1981; Chamove et al., 1982; Markowitz, 1982].

Our results support and extend the findings of Glatston et al. [1984] except that they reported the “impression” that tamarins appeared to be less active when visitors were present. One major difference in the studies was that they used much smaller cages (2.0 × 1.5 or 3.0 m) and their nonvisitor animals never saw the public, whereas monkeys in our and other studies saw visitors intermittently. Other studies too reported that visitors increase activity levels, especially when visitors harassed the animals [Lahm, 1981] or were active themselves [Hosey and Druck, 1987].

STUDY 3

The effects demonstrated in the first two studies were assessed further by observing the responses of a group of captive mandrills to zoo visitors, particularly under conditions of different visitor density. The mandrill is the largest of the primarily terrestrial monkeys, and males can weigh over 50 kg. There have been very few field studies of mandrills due to the difficulty of observing semiterrestrial animals in dense vegetation coupled with their shy nature and wide-ranging habits [Jouventin, 1975].

Methods

In the Zoological Garden of Vienna Schoenbrunn there is a stable group of three animals—one male and two females. The male and one female are Mandrillus sphinx;
while the second female is a hybrid with a drill (*Mandrillus leucophaeus*). They have been living together for 14 years in indoor (5.5 × 2.5 × 3m) and outdoor (10.3 × 2.1 × 3m) enclosures which were sparsely furnished. Visitors could approach to within .28 and .87 m of the bars of the cages respectively.

The monkeys were observed for 40 days, each animal for 10 hours per day, giving a total of 400 hours observation per animal. Half of the observations were with visitors present and half when the monkey house was closed with no visitors present. The observer (PS) sat in front of the cage and timed all the behavior patterns. These included behavior directed towards visitors such as watching and threatening; abnormal behavior such as stereotyped locomotion, masturbation, and leg and hair pulling; more general behavior such as activity, sleep, and inactivity; and social behavior such as affiliation and grooming.

**Results**

Visitors were associated primarily with altered behavior of the male, although females were affected also, and both changed more when the visitors could approach more closely, indoors. The male spent about 30% of his day watching events outside his group when outdoors, and 60% watching when indoors. Comparable values for the females were 3% and 12% respectively.

The most striking effect on the behavior of the male mandrill was his increasing attention to visitors as the number of visitors increased (Fig. 2). With every doubling of the number of visitors, the time he spent watching them also doubled.

Other behavior changed too. Threat behavior towards visitors showed much the same pattern as watching. When there were nine or more visitors, the male positioned
himself between them and the females, running in front of the bars while watching the visitors. On weekends when visitor numbers remained high, this behavior could continue for hours without interruption. Not surprisingly there was a concomitant reduction in affiliative behavior and in inactivity. Resting was not observed on the busy weekends whereas on the relatively quiet weekdays it occupied as much as 25% of the day. The male mandrill spent about 2.5 hours/day resting and sleeping when the house was closed and there were thus no visitors present. If there were any visitors about, sleeping never occurred, although he sometimes sat without moving for 10–20 min, commonly showing a genital display. When there were more than five visitors, he rarely sat still. Resting/inactivity showed a linear decrease which closely mirrored the increase in activity as the number of spectators increased.

Abnormal behavior increased by a factor of two in the presence of visitors. For example, when visitors were absent, there was no masturbation; but when there were more than five visitors, masturbation occurred about 3–7 times per day depending on visitor number.

In comparison with the male, the females showed fewer changes caused by visitors—the total elimination of grooming of other females (mandrill males are rarely groomed; Feistner, personal communication) from a level of 15% and an increase in stereotyped locomotion (plotted in Fig. 2) were the two most salient effects.

**STUDY 4**

The possibility, suggested by studies 1 and 2 above, that the amount by which different species of primates were affected by the presence of zoo visitors might itself be influenced by variables such as size and arboreality, was further investigated using data taken from 12 primate species at Chester Zoo.

**Methods**

The following 12 species of primates were observed at Chester Zoo: a group of six talapoin monkeys (*Miopithecus talapoin*, average adult weight 1.26 kg); three brown lemurs (*Lemur fulvus*, 2.0 kg); four ring-tailed lemurs (*Lemur catta*, 2.1 kg); four white-fronted capuchins (*Cebus albifrons*, 2.24 kg); six black spider monkeys (*Ateles paniscus*, 6.18 kg); four lion-tailed macaques (*Macaca silenus*, 6.78 kg); three de Brazza monkeys (*Cercopithecus neglectus*, 6.8 kg); five Sykes monkeys (*Cercopithecus albifrons*, 9.0 kg); five patas monkeys (*Erythrocebus patas*, 10.04 kg); two black macaques (*Macaca nigra*, 10.82 kg); eleven barbary macaques (*Macaca sylvanus*, 11.15 kg); and eight hamadryas baboons (*Papio hamadryas*, 25.0 kg). Average adult weights quoted are from Chiarelli [1972]. Most of these groups occupied enclosures with both indoor and outdoor compartments. The indoor cage had a glass front for the public to view the animals, and the outdoor cage was totally of wire mesh. The capuchins, barbary macaques, and baboons only had outdoor enclosures, whereas the talapoins and black macaques only had the glass-fronted indoor enclosures. More details of the animals and their enclosures are given elsewhere [Hosey and Druck, 1987].

Two behavioral measures were scored: a) behavior directed by the animals towards the audience of zoo visitors, including threat and submissive displays as well as other attempted interactions such as food begging (expressed as numbers of behavior categories per animal per 1-min observation period); b) locomotor activity
(expressed as an activity score which represented the mean number of 10-sec time samples per minute per animal that the individual was moving about rather than stationary). Behavior directed at the audience was recorded continuously during each 1-min period; activity was recorded at 10-sec intervals for each 1-min period. The animals were observed under three audience conditions: "visitors absent" was a 1-min period when there were no people at the cage; "active visitors present" was a 1-min period when at least six people were present and at least one of them attempted to gain the animals’ attention or interact with them in some way; "passive visitors present” was a 1-min period when at least six people were present, none of whom attempted to interact with the animals. A total of 483 one-minute observation periods was utilized, these being approximately evenly distributed between species, conditions, and behavior.

In order to detect differences between groups, the species means were subjected to one-way ANOVA for each of the behavioral measures. In addition, correlations were computed between the behavior shown by the 12 species and four different independent variables: 1) body weight; 2) arboreality, for reasons given above; 3) group size, since it is possible that primates in small groups are more responsive to human visitors than those in large groups simply because they get less social stimulation from their own group; and 4) mean length of residence at the zoo (the mean of the individual lengths of residence of the members of the group), since it is sometimes suggested that primates habituate to the public [Glatston et al., 1984; Snyder, 1975; Stanley and Aspey, 1984]. If this were true we would expect to see a smaller audience effect in the groups which have been at the zoo longest.

Results

Audience effects. The presence of zoo visitors was associated with a significant increase in the activity of the primates (F = 4.24; df = 2, 22; P < 0.05). This effect was particularly marked when an active audience was present, leading to a 44% increase in activity compared to the visitors absent condition. The animals also directed significantly more behavior at active than at passive audiences (F = 11.64; df = 1, 11; P < 0.01). However, passive audiences were also disruptive to the animals, and none of the 12 primate species ignored the visitors. Thus, once again, the disruptive effect of zoo visitors is demonstrated.

Species differences. The activity score of the 12 different species when an active audience was present showed a strong, but not significant, negative correlation with mean body weight, and this effect was greater in arboreal (r = -0.78, df = 4) than in terrestrial (r = -0.47, df = 4) species (see Fig. 3). This was in contrast to the correlations of body weight with the activity score when no audience was present, these being similar for both arboreal (r = -0.53) and terrestrial (r = -0.55) species. This implied that, on this measure at least, smaller species were affected more by audiences than larger species, particularly if they were arboreal. Correlations between this measure with group size (r = -0.37, df = 10) and with mean length of residence (r = -0.38, df = 10) were weak, but were both in the predicted direction, the largest and longest established groups showing the least behavioral disruption by visitors.

Behavior directed by the animals towards an active audience showed a strong, but not significant, negative correlation with both group size (r = -0.54, df = 10) and mean length of residence (r = -0.49, df = 10). At Chester, however, the groups with the largest animals tend also to be the longest established. The partial correlation
Fig. 3. Activity scores of 12 species of primate when confronted with an active audience, plotted against body weight. Open circles are more arboreal species \((r = -0.78)\); closed circles are more terrestrial species \((r = -0.47)\).

Coefficient for group size against behavior, with mean length of residence partialed out, was still in the expected direction \((r = -0.32)\), though not significant with such a small number of different groups. Body weight correlated weakly with behavior directed at the audience, but interestingly the effect for arboreal species \((r = +0.32)\) was in the opposite direction to that for terrestrial forms \((-0.28)\).

It should be pointed out that although none of these correlation coefficients were statistically significant, their strength was nevertheless impressive when we considered the likely range of variables not accounted for here that could have been influencing the response of the animals to visitors. These included, for example, cage size and shape, possibilities for hiding, frequency of arrival of visitors, etc.

**DISCUSSION**

There is clearly no simple way of predicting which species of primate is most likely to be influenced by the presence of an audience, though it is encouraging that some trends are starting to emerge from our data. In particular, the data indicate that small arboreal primates are more active than large arboreal species when an audience is present, but that the large species are more likely to interact with the visitors. In terrestrial species, too, the smaller forms are more active in comparison with the larger ones under audience conditions, although this effect is less pronounced than in arboreal species. There is also some support here for the view that primates which are in large groups or have been resident in a zoo for a longer time are less likely to interact with the audience, but we certainly cannot conclude, as have others, [e.g., Adams and Babladelis, 1977; Snyder, 1975], that zoo primates eventually come to ignore the public. Even if attempted interactions with audience decline, more subtle disruptions of behavior, as evidenced by the rise in activity, still persist.

Several recommendations for the design of primate enclosures in zoos emerge from this study. It is likely that the stressful effects of visitors could be reduced by 1) setting viewing windows high, so that only the head and shoulders of visitors are
visible to the animals; 2) increasing the heights of cages, so that the animals can become “more arboreal”; and 3) lowering public walkways, so that visitors appear smaller to the animals. Evaluation of alternatives to reduce the visibility of visitors could also be initiated; one-way viewing glass with its resulting reflection, and plants or other material could be put between animals and the viewing public.

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Cage design reduces emotionality in mice

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Summary
To see if a more natural cage design would alter the reactivity of laboratory mice, 192 mice were reared in cages with (1) no dividers, (2) five vertical dividers, (3) nine vertical dividers, or (4) nine vertical dividers and one horizontal platform. The mice preferred the most complex cages, and on almost all measures they were less emotional when reared in the more complex cages. Results suggest that a more natural housing environment would lead to healthier animals.

Keywords: Mice; Behaviour; Enrichment; Emotionality; Caging

The laboratory mouse is believed to be derived from Mus musculus wagneri, one of the wild subspecies from the dry savannah of Russia (Berry, 1970; but see Blank, 1986). Cages for their laboratory descendants are designed on the basis of requirements of the builder, of the technician, and of the animal, with emphasis on the first two. While there is little published research in the effects of cage design on the behaviour of rodents, Wallace (1963, 1964) is an exception. Because they are small and commonly preyed upon, mice are reactive animals. It is now known that reactivity is largely genetic in origin (Broadhurst, 1960; Chamove & Saunders, 1980), but its expression can be greatly modified by early experience (Denenberg, 1964; Chamove & Bowman, 1978). One of the most influential is early housing (Dawkins, 1980). Reactivity in a variety of situations appears to be intercorrelated, and researchers often use the term ‘emotionality’ as a shorthand to describe this complex phenotype.

It is known that the wild mouse lives in burrows (Berry, 1970) and that the closely related house mouse also prefers burrows (Newsome, 1969). It was, therefore, hypothesized that mice would be less reactive if reared in cages with a burrow-like structure: (a) the cage would be more like the natural environment; (b) the cage would appear to be psychologically larger (Chamove, 1989); (c) it would require more exercise/activity to move through it (Chamove, 1986); and (d) it would reduce perceived animal density (Christian, 1970). Each of these factors would be expected to reduce emotionality.

In this study, both vertical and horizontal separation were evaluated, and the degree of visual separation was also varied (Lagerspetz, 1969) in simply modified mouse cages.

Materials and methods

Subjects
Ninety-six male and 96 female albino CLFP mice, born in the Stirling University animal laboratory, were weaned at 20 days of age and used as subjects from birth. Half had been reared from birth in a partitioned experimental cage and half reared in a standard open mouse box.

Mice were housed at a regulated temperature of 22±1 °C with unregulated humidity between 50 and 60%. They were fed BP Rat & Mouse Number 3 and given water ad libitum. Ventilation was at a rate of 25 fresh air changes per hour. The room was on a 12 hour light/12 hour dark cycle which began a fortnight before conception.

Apparatus

Control cage The control cage was a standard white translucent plastic Mouse Box 1 (MB1) measuring 0.45×0.28×0.13 m which housed
the mice. In it were placed two small pieces of transparent and opaque perspex similar in composition to those used in the experimental cages as a control. They were glued in a 'T' shape so the mice could chew them as they could the partitions.

**Five-burrow cage** The 5-burrow cage was an MB1 partitioned lengthwise into five alleys of equal width using four \(0.41 \times 0.11\) m pieces of perspex \(\times 1.6\) mm thick. Each piece of perspex had a \(24 \times 40 \times 49\) mm triangular section removed at alternating ends to allow the mice to pass from one alley to those adjacent. All perspex pieces had sections removed to allow for the overhead feeder. The dividers were held in place by one upper and two lower small pieces of perspex. To pass from one side of the cage to the other, the mice had to pass up and down all five alleys and travel the length of the cage five times.

**Nine-burrow cage** The 9-burrow cage was an MB1 similarly partitioned lengthwise into nine equal alleys. The two extreme partitions had triangular sections \(74 \times 80 \times 114\) mm removed at one end to allow for a nest area when used for breeding females.

**Savannah cage** The 9-burrow savannah cage had a design similar to the 9-burrow cage except that instead of each of the perspex dividers extending from the floor to the roof mesh, the cage was divided in half horizontally by a platform of perspex. Below this platform, the cage was divided into burrows; above it the cage was undivided. The platform had a centrally cut hole \(33\) mm in diameter which allowed the mice to climb onto the upper surface of the savannah top.

Two types of dividers were used in the experimental cages: half of transparent perspex, and half of white opaque perspex. The divider design and composition was chosen so that it would be inexpensive and easy to construct, remove, and clean.

**Procedure**

The experiment was carried out in replications using the following design: \(4\) (cage type) \(\times 2\) (transparent and opaque perspex) \(\times 2\) (early experience with the partitioned cage or not).

One week prior to expected birth, two pregnant females were placed into a control (undivided) cage and two were placed into a 5-burrow (divided) cage. At weaning the pups were weighed, and marked using an ink pen, and then two groups of three littermates were housed in one of the four cage types, each cage containing a single sex group of six, half the group having had early experience of dividing cages. The floor of the cages was covered with wood chips and all cages had a \(100 \times 20 \times 2\) mm piece of clear perspex on the floor.

**Home cage testing** Food and water consumption was estimated daily by weighing uneaten food pellets and measuring water in water bottles. Animals were weighed every two days and weight gain was computed. Consumption was converted to intake per gram body weight for each cage for analysis.

Homecage activity was measured between 30 and 36 days of age when two continuous 24-h periods of activity was recorded using a radar activity monitor which records if there is movement within the cage at 4 s intervals. For analysis the behaviour was separated into activity during light and during darkness.

**Additional testing** Starting at 40 days of age a further selection of tests were performed. These were performed at 2000 h and carried out under the illumination of a 60 W bulb \(0.5\) m above the animal.

Homecage emergence was the time it took an animal to place two paws on the cage ridge when the cage top was removed. The test was done on two consecutive days and was a group test.

Box emergence was the time it took a single animal to fully emerge from a novel clear perspex box \(0.2 \times 0.2 \times 0.2\) m with an opening on one side into a clean bare cage. Slow emergence is believed to reflect high reactivity (Broadhurst, 1960).

Preference testing recorded the time mice spent in the four cage types. To do this the cage
dividers were cut in half so that two different types could be simultaneously put into the same cage. Then pairs of familiar mice were placed into these cages, one on each side, and the frequency of grooming and their locations were recorded at 10 s intervals for 8 min. Each animal pair was given six choice tests with all possible pairs of dividers presented in a random order. The animals could choose to spend time on either half of the cage, each with a different divider patternning.

Open Field testing involved placing a mouse onto a flat white circular platform 0.6 m in diameter illuminated by two 100 W bulbs 0.5 m above the platform. It was surrounded by a white sheet 0.2 m from the edge of the platform and was 0.6 m above the ground. The floor was marked into 19 segments as described in detail in Chamove and Saunders (1980). Grooming, ambulation, and faecal elimination were recorded when these occurred, the first as duration, the second as number of segments crossed, and the third as bolus number.

Adrenal weights were measured from 160 animals from a pilot study using similar variables. Between 40 and 42 days of age, animals were killed by neck dislocation. One adrenal gland was removed, cleaned of fat and connective tissue in 0.9% saline, and weighed.

**Statistical analysis**

A repeated measures analysis of variance was used which was of the form groups (4) x early experience (2) x perspex type (2) x sex (2) x measures (when applicable). Although sex was a factor in the study, its inclusion was to reduce variance and it was not of interest in itself. Alpha was set at 0.01 throughout, and all results reported are significant beyond this level unless specifically stated otherwise. This level was chosen as the number of animals was quite high and important differences only were sought.

**Results**

**Home cage testing**

There was significantly less activity and movement recorded from control cages than from the 5-burrow or 9-burrow cages ($P<0.01$), while activity in the savannah cages was not significantly greater than in the control cages (see Fig. 1). The lower level of activity in control cages was especially apparent during the daylight period. It was also noted by animal-care staff that there was less fighting in and vocalization from the three types of partitioned cages, especially the two 9-burrow cages. While there was no difference in the amount eaten or drunk in the four types of cages, those from the control cages had a significantly lower mean weight gain over the 18 days after weaning than those in the three burrow cages ($P<0.01$; see Fig. 1). Time to emerge from the home cage was significantly faster for the control group than for the other three cage types ($P<0.001$; see Fig. 2).

![Figure 1](image1.png)

**Figure 1.** Twenty-four hour activity levels in the home cage over 2 test days (left), and weight gain from weaning weight over 20 days (right).

![Figure 2](image2.png)

**Figure 2.** Time to emerge from the home cage (left) and from a novel box by mice from the four rearing conditions.
Other testing
Time to emerge from a novel perspex box into a bare cage was significantly slower for the control group than for the three experimental groups ($P<0.01$; see Fig. 2).

Open-field testing showed that the control group was the most reactive, the 5-burrow group was intermediate, and the two 9-burrow groups were the least reactive in the test ($P<0.0001$). As can be seen in Fig. 3, the control group crossed the least number of lines, deposited more fecal boluses, and groomed themselves most in this test.

Adrenal weight relative to body weight in the 5-burrow (0.0123 g) and 9-burrow (0.0120 g) group was significantly less than that of the controls (mean = 0.0134; $P<0.025$), but the savannah groups' adrenal weights were not (0.0133 g).

There was a clear preference for all groups for the more complex cages when given such a choice (see Fig. 4). When they showed a significant preference, which they did on 66% of tests, they chose the more complex cage 89% of the time. The few exceptions were primarily when the 9-burrow cage was paired with the 5-burrow cage where there were four reversals, and when the savannah cage was paired with the 9-burrow cage where there were three reversals. The control half of the cage was only reliably preferred once in all the 16 categories of tests, that is in the five opaque males when compared with the 5-burrow opaque condition.

Early experience
The significant effects of spending the first 20 days of life in 5-burrow cages were few and were not consistent. Those with this early experience gained weight less rapidly, but ambulated more and defecated less in the open field suggesting lower emotionality.

Opaque/transparent perspex
The significant effects resulting from the type of perspex used were also few and inconsistent. On the one hand those with opaque perspex ate and drank more but had less weight gain. They groomed more in the preference test and had greater adrenal weights suggesting possibly higher reactivity.

Discussion
The results of this study clearly showed that the presence of vertical partitions in the cages of mice reduced the stressfulness of caging and also led
Mouse cage design and emotionality

...to mice which were less reactive when tested outside their cages. It appears that dividing the cage into nine was better than dividing it into five which was better than the normal mouse cage with no divisions at all. An additional horizontal division into a savannah did not improve the cage, although a partial horizontal division might be preferable.

When reared in the more complex cages, the animals gained more weight and were more active; they emerged from a novel box more quickly; they walked more, defecated less, and groomed less in an open-field, and they had smaller adrenal weights. While low adrenal weight and high growth rate can be judged as being 'good', it is more difficult to assess the behavioural characteristics. Nevertheless, all of the results suggest that mice were under less stress and were less emotional.

All mice preferred the more complex of the cages. The mice from the complex cages were slow to leave these cages to enter an open area, whereas those from more open cages left more rapidly.

Whether the dividers were opaque or transparent appeared to have little consistent effect on emotionality. The effects of early rearing in the complex cage were not clear and few differences emerged. Those that did were consistent with the view that early experience in a more complex cage may lead to lower emotionality. The change from a more open cage to a more complex one may also have benefits, and a number of studies suggest that brief early stress may be beneficial in reducing later stress (reviewed in Chamove, 1989).

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References
Part 4: Enrichment--Social

Vision


Deprivation of Vision in Social Interaction in Monkeys
Arnold S. Chamove

One way of assessing the role of vision in social development has been to observe and test individuals with visual impairment. Observations from such studies impress one with the lack of any reported effects of visual deprivation on personality and behavior (Chamove, 1965, and reviewed by Dinnage, 1972). Unfortunately, one is also impressed with the poor design of most studies and other restricted studies reported in the literature (Imamura, 1965). However, findings blind children more dependent and compliant, and often the speculation that the blind cannot cut off steam by being aggressive. Few studies, though, mention any abnormality in hostility.

Of the infrequent studies of social development in blind monkeys, most have been on how naturally-blind or blinded infants what has been learned by Berkson (1974). They are especially concerned with the behavior of others towards these debilitated animals. But the blind monkey infant, like the blind human infant, is carefully trained, helped, and guided to model its behavior after, and therefore success fully interacts with individuals with normal vision. Also like human infants, the blind monkeys are usually reared and controlled by sighted individuals. They are usually in situations where another individual, usually sighted, is dominant. It is not surprising that in studies of blind children (and even of normal vision), unwritten attitudes are often found to override other factors of development.

The present restrictions make it difficult to observe the uninfluenced behavior of blind individuals to see how they would differ from the sighted. To observe the unique individuality involved with the inability to see, one ideally needs two conditions: the blind individual interacting solely with other blind individuals, therefore unhindered; and an experimentally-induced reversible blindness, both to allow evaluation of what has been learned and also to ensure that the inability to see is the only deficit of the individual.

We have developed such a paradigm in our research by using monkeys that are given all of their social experience in the dark. As the purpose of this study was to delineate the role of vision in social development, the only deprivation imposed is that specific component of social experience that is visual.

Method

Eight stumptailed macaques (Macaca arctoides) were separated from their mothers within one week of birth. They were reared alone in cages where they could not see other infant monkeys. Although they could hear and smell them. The monkeys could, however, see masked humans carrying out maintenance chores. Milk was available ad lib from bottles, and soon after separation the infants were self-feeding (Chamove, 1975).

At three months of age social experience was first allowed. Four of the infants served as controls. They were allowed to interact daily in pairs or fours with others from the same group (as in Chamove, 1973). This was done by removing the partitions between adjacent cages—the cages being identical and measuring 2.1 m by 8.6 m by 12.2 m high (approximately 23 ft. 5 in. by 28 ft. 4 in. by 40 ft. 3 in.). The remaining four infants were treated identically except that just before the dividing partitions were removed to allow social interaction, the lights were extinguished and remained so for the duration of the social interaction and until after the opaque partitions were replaced. This group was termed the visually socially deprived, or VSD, group.

Each group had daily peer interaction only with other similarly deprived monkeys—that is, the VSD monkeys only interacted within the VSD group and the control monkeys only within the control group. The variables, then, were: The VSD were (a) deprived of vision when socially interacting and (b) also restricted in their interaction to only other VSD monkeys. The second variable ensured that neither group was handicapped by being with monkeys more sophisticated or competent than themselves.

The behavior of the VSD group was observed each day using an infra-red video television. At 12 months of age, both groups were tested in the light.

Results

Although detailed analysis is not yet complete, several interesting and unexpected results have emerged. Contrary to what was expected (Parker, 1966), both groups spent most of their hour of social interaction engaged in complex and active social play. In fact, it was difficult to distinguish between the two groups. This is similar to Berkson and Karrer (1968), who stated, "in a familiar environment the blind animals appeared normal..." (p. 173). It was only toward the end of the study that we realized that we had never observed any aggression, neither aggressive nor contact behaviors such as biles, in the VSD monkeys.

Whereas aggression developed as expected in controls at about six months.

The complete absence of hostility in these visually-socionally deprived monkeys was not because all behaviors were suppressed; they clearly were not. And it was not because they could not distinguish other animals, for they showed strong preferences for particular partners.

When later allowed to see other familiar and unfamiliar monkeys, aggression appeared normal in spite of still being low in frequency compared with controls. When subsequently tested in the dark once again, their aggressive levels were higher than before visual-social experience.

These preliminary results suggest that (a) seeing others during social interaction is not essential for adequate social development; (b) the balance of active behaviors is altered by the absence of visual social stimuli; (c) the absence of social cues, usually releasing stimuli for aggression, alter the expression of aggression both in short and long term in a way unexplained by current theories of aggression; (d) the role of vision in social development may be more specific than that suggested by the literature.

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Role of Vision in Social Development in Monkeys

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One way of assessing the role of vision in social development has been to observe and test individuals with visual impairment (Partridge & Pitcher, 1980). Observations from such studies on humans impress one with the lack of any gross effects of visual deprivation on personality (Zahran, 1965; reviewed by Dinnage, 1972), on intelligence (Van der Kol, 1977), or on social behavior (Dinnage, 1972; Fraiberg, 1974, 1977; Norris, Spaulding, & Brodie, 1957), although spatial perception is understandably affected (Spigelman, 1976; Von Senden, 1960). In one of the few well-designed studies of social development in the blind, Imamura (1965) compared 10 blind 3-6-year-olds with 12 controls and found some surprising behavioral differences. The blind were found to interact with people more than sighted individuals. This effect did not depend on type of partner; that is, the blind did not prefer to interact with the mother relatively more than with other people. This finding of normality of preference was not confirmed by the results of Burlingham (1961), who reported that many blind people showed abnormal bonding relationships. However, Fraiberg (1977) found that the blind showed a normal development of preference, at least for the mother versus strangers. Earlier she states, “Something vital is missing in the social exchange, a resonance of mood” (Fraiberg, 1974, p. 217), although the development of attachment to others is normal.

Imamura found no difference in the tendency to instigate behavior with the mother, but found that the blind did instigate less frequently with others, which he interpreted as their having less initiative. The blind were found to exhibit a greater rate of behavior, especially succorance and sociability behaviors, but presented less variety of behavior— that is, were more repetitious. Succorance was clearly the most prevalent behavior for the blind, but not for sighted children. The blind showed half the amount of dominance (control or assertive behavior), one-third the amount of “nonsocial” (antisocial) aggression, equal amounts of submission, and more succorant behavior in comparison with sighted children. Imamura (1965) speculated that the blind cannot “let off steam” by being aggressive.

This lack of assertive behavior in the blind confirmed earlier findings, although unassertiveness was not stressed either by Imamura or by earlier researchers. Burlingham (1961) had to teach and encourage nonsocial, physical aggression in one blind patient. Imamura suggests that his findings are similar to a study by Barker, Wright, and Gonick (1946) on children with other physical disabilities and concludes that it may not be blindness per se but the physical handicap or resulting overprotection that changes behavior (see also Schnittser & Hirshoren, 1981).

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[Child Development, 1984, 55, 1394–1411. © by the Society for Research in Child Development, Inc. All rights reserved. 0009-3920/84/5504-0052$01.00]
More detailed analysis by Imamura revealed even more differences. Behaviors involving physical action were equal in frequency in the blind and sighted, but the blind performed more gestural and verbal acts than the normal children. Only 22% of the blind children's acts were physical (involved contact), whereas 30% of the sighted children's were.

Other studies that report differences between the blind and normally sighted individuals are more general in their approach, with the finding that the blind are less outgoing (Petrucchi, 1953; Sandler & Wills, 1965; Schnittser & Hirshoren, 1981).

More recently, those interested in the role of vision in social interaction have used observation of visual interaction in normal individuals (see, e.g., Rutter, 1973). Gergen, Gergen, and Barton (1973) began by manipulating the environment using sighted individuals. They observed groups of unfamiliar university students when in the dark for periods of 60—90 min. They report less talking, more movement, and more physical contact than groups of control strangers in the light.

Most of the work manipulating light levels with animals has involved documenting the effects of reduced levels or patterning of light on physiological development (Riesen, 1965; Von Noorden, Dowling, & Ferguson, 1970; Weiskrantz, 1972). A few studies have looked at the role of vision in social interaction. Lagerspetz (1969, p. 83) observed mice bred for increased aggressiveness and reported that "motion of the target was necessary for the occurrence of aggression, and also increased its intensity." Davanzo (1969) looked at the effects of blindness on isolation-induced aggression in mice. Although subjects blinded after isolation revealed no differences in aggression when compared with sighted controls, those blinded before isolation suffered retardation in the development of aggression and performed at a level 50% below sighted controls after 7 weeks of isolation and 10% below controls after 9—12 weeks of isolation.

Of the few studies of social development in blind monkeys, most have been done by Berkson and associates. Three monkeys with induced corneal cataracts were reared for 3 months (Berkson & Kar rer, 1968) or 6 months (Berkson, 1974) with their mothers; "In a familiar environment the blind animals appeared normal on superficial inspection" (Berkson, 1974, p. 173). Although all showed some threat and self-bite subsequent to maternal separation, there was almost no threat by the blind subjects when they were observed at 9 months (probably observed alone in a cage). Five blind long-tailed macaques (Macaca fascicularis) (Berkson & Becker, 1975) showed no threat face. In the wild (Berkson, 1977), mothers were especially protective of blind offspring. The blindness affected others also, and surprisingly no instance of aggression toward the blind animals was ever seen. There was no effect of blindness on the quality of the relationships of the blind subjects with other animals. The only behavioral difference reported was the high level of fear-grin in the blind monkeys.

Monkeys reared in pairs in the dark for the first 3—6 months of life were reported to be relatively unresponsive in visual tests, and it was briefly noted that they were more fearful in general (Regal, Bothe, Teller, & Sackett, 1979). In a pilot study, Chamove (1978) gave four macaques all of their social experience in the dark. In comparison with all-light controls, these restricted animals showed almost no aggressive behaviors but few other differences in social behavior.

The above studies summarize what is known about social behavior in the blind. These describe behavior in the blind but tell us little about the role of vision in social interaction. The blind human infant is carefully trained, helped, and guided to model its behavior on and therefore successfully interact with individuals with normal vision. Also the blind are often in situations where another individual, usually sighted, is dominant. It is not surprising that in studies of blind children, as for children with normal vision, parental attitudes are often found to override other factors of development (Zahn, 1965).

These and other restrictions make it difficult to observe the uninfluenced behavior of the blind individual to see how it would differ from the visually normal. To observe the unique qualities involved with the inability to see, one ideally needs two conditions: the blind individual interacts only with other blind individuals, therefore not relatively handicapped; and an experimentally induced reversible blindness, both to allow evaluation of what has been learned and to ensure that the inability to see is the only deficit of the individual. By using monkeys that are given all of their social experience in the dark, we are able to study the role of vision; and by restricting the subjects' "blindness" to social situations, we are able
to restrict our deprivation only to visual social interaction.

**Method**

**Subjects**

Eight newborn stump-tailed macaques (Macaca arctoides) were selected from consecutive births and separated from their lightly anesthetized mothers at 5 days of age, with the restriction that separation weights be within 1 SD of the mean of 62 normal separation weights (Chamove, 1981). Eight such monkeys were selected from nine born between May 26 and July 12, 1976, from multiparous wild-born mothers. They were formed into two groups of one male and three females in each. The age range of the first group was 37 days and of the second was 6 days; 28 days separated the means of the two groups.

Subjects were trained to feed themselves within about 24 hours, as described elsewhere (Chamove & Anderson, 1983), and were housed with a diaper in individual mesh cages measuring 65 x 60 x 60 cm. They could hear and smell but not see other monkeys, although they could see masked humans. These cages had solid, removable, opaque white Perspex sides, which projected out from the cages so that animals could not contact others in adjacent cages. Removal of these sides allowed the cage area to be doubled when subjects reached 12 months of age, and it allowed eight cages to be interconnected in one continuous row when subjects were 21 months of age.

Animals were weighed daily at 10 A.M. by a masked technician until they reached 76 days of age and on three consecutive days at monthly intervals thereafter until 346 days of age. Milk was continuously available and was the only food offered until 106 days of age, at which time solid food and water were gradually introduced (for details, see Chamove, 1981).

**Apparatus**

Two test cages were used in this study. One, a large mesh rectangular cage 86 x 2.88 x 1.20 m and painted blue, was briefly used as a novel cage. The other, a black mesh cage, termed the "wedge cage," was 2.4 m long, 1.5 m high, and measured 65 cm wide at the narrow end and 3 m wide at the broad end; it was used throughout the experiment. This cage was designed so that a television camera had an unimpeached view from a single position while maximizing the cage area. This cage was located in a room that could be completely darkened. The cage was then viewed through a wall-mounted end panel of glass. On the other side of the glass window was mounted a monochrome Jackson model CIT-10 television camera with a silicon Vidicon tube (type 20 PE-13A) for infrared sensitivity. The addition of six infrared lights mounted behind a pair of infrared Wratten filters (Kodak no. 87) allowed audiovisual recording of the behavior of the occupants of the Wedge cage on a Sony Video recorder (model 3260-CE) and viewing on a National video monitor (model VW 5319E/B).

Most data were recorded using a data transfer unit (DTU) of our design. The DTU was a device that transferred onto punched paper tape the information coded by depressing sequences of buttons together with automatically produced time information. The punched paper tape was computer analyzed, producing information on bout length and durations of each behavioral combination. The duration was expressed as percentage of the total time observed, and the bout length was the average duration of each event (details in Chamove, 1974).

**Procedure**

This study can be divided into two parts. The first part involved the rearing period when the dark group were tested only in darkness; the second part was a postrearing period involving (a) social group testing for overall group differences, (b) individual nonsocial testing, and (c) other special tests that further tested the main hypotheses, clarified the effects from prior sections, and/or ruled out potential confounding factors.

**Longitudinal testing.**—Beginning at 2 months of age, each monkey spent 2 hours each day alone in the wedge cage with milk and its diaper; this served as an adaptation period. Monkeys always had a diaper present with them when in the wedge cage until about 1 year of age, when they began eating them, and then were replaced with plastic bottles. At 3 months of age the adaptation period ended and daily pairwise social experience was begun and continued throughout testing. Each monkey received a minimum of 2 hours of social experience a day 6 days a week until the end of testing at 21 months of age. At this time they were housed in two groups of four in their home cages. Throughout these 21 months the monkeys had experience only with other members of their own group. Social experience for a given group was either only in darkness or half in darkness and half under normal lighting conditions.
Social testing was carried out using a similar procedure to that of daily social experience. Testing was done at ages 3, 9, 15, and 21 months of age. Half of the testing was done in groups of two and half in groups of four. Each animal was tested in every condition it experienced, a minimum of four times with each of the other three animals in its group and a maximum of eight times in a group of four. This meant that behavior could be recorded on two occasions using each animal independently as a subject for observation. The behaviors recorded are those described below.

Two conditions of test were used: (1) testing in darkness, and (2) testing in normal lighting conditions. The light group was always tested and given social experience under both of these conditions; the dark group was tested and given all of its social experience in darkness only. All monkeys were housed under normal lighting conditions.

When the first four monkeys averaged 3 months of age, their social experience was begun, and they were termed the "light" (L) or control group. The second four monkeys reaching 3 months of age were designated the experimental or "dark" (D) group. The presence or absence of light during the 2-hour daily encounters with other animals was to be the only difference between the two groups. The dark group never saw other monkeys; the light group saw other monkeys on alternate days. Daily social experience was always in pairs. Testing in fours only occurred during the four test blocks and then after the pairwise tests had been given.

Brief testing.—One week after 21-month testing was completed and just before group housing was begun, a 30-hour dark test was carried out. All four animals of a group were placed together in the darkened wedge cage at 10 A.M. and remained there for 30 hours. Normal feeding at 5 P.M. and 9 A.M. was done in the dark, and water was continuously available. The subjects were observed for 25-min periods at 10 A.M., 11 A.M., 1 P.M., 4 P.M., 11 P.M., 11 A.M., and 4 P.M.

Just prior to group housing at 21 months, and 1 week after the 30-hour dark test, a 30-hour light test was carried out. The procedure was exactly the same as for the previous 30-hour dark test, but it was carried out under normal lighting levels. After the four animals of one group were placed in the darkened cage and the video was on for 1 min, the lights were gradually increased to normal levels over a period of about 5 sec, and testing begun. The lights were left on for 30 hours. This was the first social experience in the light for the dark group.

The third brief series of tests was termed the "mixed test." Animals were tested in their living groups of four at 24 months of age. Their social interactions were observed for 25-min periods during the following conditions: (1) normal baseline social housing, (2) milk competition, (3) unfamiliar room, (4) reunion after 24-hour separation, (5) 3-month-old infant, (6) adult male, (7) novel object, and (8) novel object in dark.

The baseline test involved observing in the normal social housing group of four on 2 days consecutively before the other mixed tests and on 2 days afterward, the 4 days being averaged. The milk competition test used the standard dominance competition procedure. A single bottle of highly desirable milk was introduced to the group, resulting in competition for the milk by the group members. Typically, a clear dominance gradient can be seen that is closely related to the hierarchy assessed after deprivation of water or from the results of agonistic encounters (Chamove, 1983; Clark & Dillon, 1973). The milk spout was made smaller than normal to prolong the test. This was designed to increase the frequency of affiliative and aggressive behaviors and also to assess the dominance order. This test was repeated 3 days after its first administration, and the results were combined.

For the next test, subjects were carried to an unfamiliar cage in an unfamiliar room, and they were placed together in the blue test cage for 1 hour. This test was designed to increase the occurrence of affiliative behaviors. For the next test, the home cage was divided by opaque partitions into four segments, each with one animal. After 24 hours the partitions were removed, and the behavior during the first 25 min of reunion was recorded. Then two tests using unfamiliar stimulus animals. In the first a 3-month-old infant stimulus monkey was placed in the cage with the four subjects. In the second a docile male adult stimulus monkey was introduced into the cage with the subjects. The former was designed to allow aggressive behavior, the latter to elicit an increase in withdrawn and affiliative behaviors. The novel toy light test involved the introduction of an unfamiliar black rubber cylinder about 30 cm long and 10 cm in diameter. Black was chosen so as to be more frightening. The novel toy dark test was similar, but it used a ticking clock
as the novel object; this last test alone was done in darkness.

These eight tests were done in the above order and were begun every day at 11 A.M. All tests lasted for 25 min. The following behaviors were recorded: withdrawal, exploring, play, aggression, and affiliation. These were subdivided into two types—contact and noncontact, and into direction—either self-directed, directed toward one of the three other animals (animal specified), directed toward a nonsocial aspect of the environment, or directed toward the stimulus object if there was one. They are defined as follows: withdrawal—all behaviors that reduced the amount of sensory input; exploring—all behaviors that increased the amount or variability of sensory input; play—behaviors that established more complex interaction patterns with objects through utilization of information gained in exploration; aggression—behaviors that structured the social environment in a manner maximizing the number of prerogatives; affiliation—behavior that reduced emotionality in the subject or in another animal (discussed in Chamove, 1974; Chamove, Eysenck, & Harlow, 1972).

During the 30-hour tests, a metronome produced a tone every 3.7 sec. Between every 3.7-sec interval, a different focal animal was observed and the presence or absence of the above behaviors noted on a 0-1 basis. Every monkey was observed for 100 3.7-sec intervals. During the mixed tests the metronome sounded every 15 sec; since all monkeys were observed in every interval, each monkey was tested for 100 intervals.

Preference.—It was considered desirable to ascertain if monkeys in the dark could discriminate between partners as well as monkeys in the light; if so, would they develop as extreme preferences for their partners? To test the hypothesis that vision is important for discrimination and preference, it was predicted that the variability of a monkey's positive or negative behavior toward its three different partners would reflect its discrimination of and preference for the partners; for example, a monkey with a strong preference for monkey P would show relatively more positive behavior and relatively less negative behavior toward P than toward the others. Thus the standard deviation of its scores toward the three partners would be greater than a monkey whose scores toward its partners were more similar. To test this prediction, standard deviations were computed separately for contact and noncontact socially directed play, aggression, affiliation, and withdrawal behaviors for the three groups using longitudinal pairwise data for each of the four test months. These were averaged to give four monthly scores for each monkey for each behavior, and an analysis of variance (ANOVA) was used to assess the differences.

To obtain a second measure of the above and also to reduce a possible source of variance in the analyses of social interaction, another measure of preference was made. The literature suggests that, in social tests using individuals, little attention is paid to the injection of variance due to the possibility that monkeys will have different preferences for their partners either when tested in pairs or in larger groups of animals. To my knowledge no one has attempted to analyze or control for this source of variance, although it is commonly acknowledged to exist. When the groups had been living as groups in the light for 1 month, an estimate of preference was made using the wedge cage in lighted conditions. The wider half of the wedge was divided into three channels by the insertion of white, opaque partitions. At the end of these channels, in transport cages, were placed a monkey's three housing partners. A monkey was placed in the narrow half of the wedge for 1 min, during which time it was restrained from leaving that half by transparent Perspex, but it could see into the channels and down the channels into the transport cages where its group mates were kept. At the end of the adaptation minute the Perspex was removed, and the monkey could enter any one of the channels and approach to within 3 mm any one of the other monkeys during the 25-min test. A record was made of the percentage of choice time (in a channel) by each animal toward each partner as well as the type of behavior exhibited by the monkey while making its choice. Order of testing and of position in the transport cages were randomized. For the data analysis two numbers were computed for each pair of monkeys: the percentage of choice time per monkey relative to choice time towards other monkeys, and percentage of relative choice time minus choice time spent in aggression. If a preference ranking based on the two tests did not agree, a second test was given, the latter estimates compared, and if not agreeing, more tests given. From this test a ranking of partner preference was obtained and termed least preferred, intermediate preferred, and most preferred partners. These rankings were used in the analyses of behavior over the previous 21 months and for the mixed tests as best unbiased estimates of preference. A discussion of the correlation of
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The results of this test were used also as a secondary test of the hypothesis that individuals in the dark have less pronounced preferences than those in the light. To do this a single score was computed for each individual based on the sum of the three differences of percentage positive preference scores between each pair of possible partners. An individual with strong preferences would be expected to have a wider range of time spent with each subject and therefore a larger sum-of-difference score than an individual with a less strong preference. The scores were subjected to a two-tailed t test.

Self-aggression.—At 16 and 20 months of age, each subject was observed when alone in its home cage on 2 days consecutively for 30 min each day, and the amount of time spent exhibiting self-aggression was recorded with a stopwatch. The 2 days were averaged, and the data were analyzed using an analysis of covariance with sex as the covariate and age as repeated measures. Males are known to be more self-aggressive than are females (Anderson & Chamove, 1980; Chamove & Harlow, 1970).

Dominance stability.—Although the relative stability of any type of interaction might be affected by visual experience, the stability of the dominance hierarchy is one that can be easily measured. If aggression is affected by visual social restriction and if dominance hierarchies are formed by aggression, then one might expect deficiencies in dominance hierarchies in the dark group (see Deag, 1977; Rowell, 1974). Since most of the social experience was in pairs, it was possible that pairwise dyadic dominance relationships were set up that were only challenged at 6-month intervals when tested in groups of four. After the testing in fours at 21 months, two 30-hour tests were given as described above: the first in fours in darkness, the second in fours in the light. After this test, two milk competition dominance tests were performed. Two measures of dominance stability were assessed. First, a dominance ranking was assigned to the subjects based on the results of the milk competition tests. The time to drink for 30 sec and 60 sec were computed for each animal and subjected to an analysis of covariance (ANCOVA). The more unstable the hierarchy, the longer subjects might be expected to take to accumulate the 30 or 60 sec of drinking time, due to interruptions and fights. Second, that same dominance ranking also was used in assessment of the prior 30-hour tests. If dominance was stable, one would expect relatively little aggression to be directed toward those above one and little fear to be directed to those below one in the hierarchy. The percentages of these "inversions" of aggression plus withdrawal behaviors were calculated for each of the seven tests over the two 30-hour periods, and groups were compared using an ANCOVA. It should be noted that for the dominant animal it was not possible for it to produce an inversion for aggressive behavior, but it was possible for withdrawal behavior; for the subordinate any aggression was an inversion, and all fear appropriate to its position.

Fear test.—Five of the mixed tests that were designed to increase the level of fear behaviors were used to see if the dark group differed from the light group in the levels of fear exhibited in novel situations. The tests were ranked on the basis of prior data (Anderson & Chamove, 1980) in terms of novelty, and the scores of withdrawal directed toward the novel object were evaluated with an ANCOVA. The tests used were, in ascending order of fearfulness, novel toy, novel room, infant stimulus, dark toy, and adult stimulus monkey. The behaviors measured were as described above.

Analyses

A repeated-measures analyses of variance (ANOVA) or analyses of covariance (ANCOVA) were used to assess the effects of experience in darkness, either comparing behavior between the two rearing groups or comparing between dark and light social experience conditions within the light group (here also termed "group" comparisons for convenience). Six ANOVAs assessed the longitudinal pairs tests. The first two compared behaviors of the dark group while in the dark, DD, with the light group while in the dark, LD; the second compared DD behavior with LL behavior—that is, dark group in the dark with light group in the light; and the third compared behavior of the light group when in the dark with their own behavior in the light, LD-LL. It should be stressed that this latter comparison was a within-groups analysis and involved a repeated-measures ANCOVA. It should be further noted that, in the above three pairwise comparisons, the same data was used twice in different analyses. Although this does not alter alpha per comparison, it does alter alpha per experiment.

In these ANOVAs, age (subdivided into 3, 9, 15, and 21 months) was a repeated measure, as was behavior type (subdivided into
contact or noncontact), direction (social or nonsocial), and partner (most, intermediate, or least preferred partner). Two additional repeated measures subdivided behaviors into play, aggression, affiliation, and withdrawal behaviors; the first two and last two of these behavioral subdivisions were designated as less and more assertive behaviors; the first and third were termed positive; and the remaining two more negative behaviors. The first of each pair of ANOVAs used percentage as the measure of behaviors, and the second used bout length. Fisher’s LSD tests were used subsequent to significance for more detailed comparisons.

A comparable set of six ANOVAs were used to analyze behavior during the 21 months of longitudinal tests in groups of four. The use of as few as 12 ANOVAs was intended to reduce the inflation of alpha per experiment as much as possible (Li, 1966). Three ANCOVAs were used to analyze the three brief tests at 2 years of age. The same four behaviors were analyzed as above, the same type condition, but direction was subdivided into self, the same three levels of partner (least, intermediate, most preferred), and other (e.g., the object or the stimulus monkey). The repeated tests were another repeated measure in the ANOVA, seven repeated measures at the different times in the case of the 30-hour tests, and eight different tests in the mixed test.

An ANCOVA was performed on the weight data from 3-day averages taken at 76, 106, 136, 166, 196, 226, 286, and 346 days of age. The purpose of this analysis was to ascertain if body weight might be a confounding factor in social behavior. These are two examples: a heavier animal would have an advantage in a dominance test; the dark group might be under more stress from their experimental regime than the controls and might therefore gain less weight. The first value, weight just before the experimental treatment was begun, was used as the covariate in order to reduce the within-group variance by removing any variability resulting from initial weight differences between the animals.

All analyses were two-tailed, and alpha was set at .05 unless specifically stated otherwise. All ANCOVAs used dominance rank, as determined from the milk competition tests, as the covariate unless stated otherwise. The reason for this was to try to reduce the within-group variance. It was suggested that a history of occupying a particular dominance position would influence social behavior (Chamove, 1980, 1983) and removing the variance from this factor would make the subjects within a group more homogeneous. As the same covariate values are used for each group, it was appropriate to use unadjusted means in the figures involving ANCOVAs.

Results—Rearing Period

Longitudinal Pairs

Percentage.—Figure 1 depicts the results of ANOVAs comparing DD with LD, DD with LL, and the within-groups comparison of LD with LL. Figure 1 illustrates the significant interaction of groups DD-LL and LD-LL with age × assertive behavior, F(3,18) = 4.87, p = .01, and F(3,9) = 5.25, p = .02, and also age × positive behaviors, F(3,18) = 3.26, p = .049, and F(3,9) = 15.4, p < .001. As affiliation rarely occurred and was almost identical in the different groups, it is not plotted here. The important age differences are reflected in the 3-month block compared with the 15- and 21-month blocks, which are very similar and are averaged together in Figure 1. It illustrates that the LL, in comparison with both DD and LD, exhib-

![Fig. 1.—The group × age × behavior interaction for pairs testing. Where summing over all four age blocks, the lower segment of the bar indicates the average of socially directed behavior, the upper the average of nonsocially directed behavior; 18 is the mean of months 15 and 21.](image)
lted more play and aggressive behaviors at 3 months of age.

In the same figure, the effects of age were averaged to give a histogram which is subdivided to illustrate direction. This reflects the significant behavior (assertive × positive) × direction effects for both the DD-LL comparison, \( F(1,4) = 9.64, p = .03 \), and the LD-LL comparison, \( F(1,3) = 10.22, p = .046 \). It reveals that the LL showed more socially directed play and more socially directed aggression and less nonsocially directed withdrawal than did the DD and the LD throughout the 21 months of tests (see also Figure 6).

The more interesting DD-LD comparison revealed only two significant effects, both of which pertained to the direction of social behavior: age × direction, \( F(3,18) = 5.32, p = .008 \), and age × behavior × direction, \( F(3,18) = 3.56, p = .03 \). The first of these is seen in Figure 2, which depicts the strong preference for nonsocially directed behavior over socially directed behavior in the DD at age 3 months, the slight preference in LD, and the reversal in the LL. With increasing age the preference for social direction reversed in the LL and approached that level characteristic of the DD group. Although not interacting significantly with behavioral type, this effect is demonstrated most clearly for nonsocially directed behaviors (connected symbols in Figure 2).

The other significant DD-LD effect, age × behavior × direction, is not illustrated but appears to reflect the relatively high level of socially directed affiliative behavior in the LD group at 3 months of age and its decline to a low level by 21 months of age, although the total levels of affiliation were similar for all groups.

There were more significant effects in the percentage analyses. In comparison with both groups of subjects when tested in darkness, the LL revealed more of both contact and nonsocial forms of the two assertive behaviors (play and aggression) in the first two test periods. The DD were showing less of all of the four behaviors during the first test period than the LL group. The light group showed more nonsocial behaviors in the first month when tested in the light than when tested in darkness.

**Bout length**—Analysis of bout length on the same pairwise longitudinal tests led to additional significant effects in what was perhaps the most interesting comparison of DD with LD: Figure 3 illustrates the age × contact, \( F(3,18) = 3.66, p = .03 \), for DD-LD, and \( F(3,9) = 3.93, p = .048 \), for LD-LL, and overall contact/noncontact interaction with all groups. In Figure 3 it can be seen that the DD had contact behaviors with shorter bout lengths early in life than the LL, which surprisingly had shorter bouts than the LD. These effects cannot simply result from low levels of the long bout-length behaviors—for example, withdrawal—as the dark group animals exhibited shorter bout lengths for all behaviors, but relatively lower values in the longer bout-length behaviors, withdrawal, play, and affiliative.

In the DD-LD bout-length comparison, behavior interacted with age, \( F(3,18) = 3.00, p = .047 \). Bout lengths were shorter for DD in the first two age categories for the behaviors withdrawal, affiliation, and play; but these differences were not so clear in the final two age categories.

Partner preference also interacted with DD-LD, \( F(2,12) = 3.07, p < .05 \), as can be seen in Figure 4. Whereas the light group in
both the LD and LL conditions revealed longer bout lengths when paired with their most preferred partner, the dark group actually had lower values. This effect also interacted with behavior; the dark group showed shorter bout lengths toward their most preferred partners when playing but longer bouts of withdrawal toward their least and intermediate preferred partners when compared with the light group under the two test conditions.

There were a few interesting effects in the LD-LL comparison. In the partner \( \times \) behavior \( \times \) age interaction, \( F(6,36) = 3.32, p = .02 \), during months 3 and 9, the LD animals had much longer bout lengths of withdrawal when with their least preferred partners and much longer bout lengths of affiliation when with their most preferred partners than LL animals. Another interesting effect in the same comparison was the main effect of group, \( F(1,6) = 11.31, p = .04 \).

The LD had longer bout lengths on average than did the LL; this effect tended to be strongest for withdrawal and for affiliative behaviors.

**Longitudinal Fours**

The data collected during longitudinal testing of groups of four suffered from technical problems. Only the DD-LD and DD-LL comparisons were available for month 3 and the LD-LL only for months 3 and 9.

No DD-LD comparisons from month 3 were significant. The single significant effect of bout length from the DD-LL comparison at 3 months revealed bout lengths over twice as long for the LL in social play, social withdrawal, and social and nonsocial aggression, \( F(1,6) = 6.76, p = .04 \).

The following nonsignificant trends were evident as early as 3 months, confirming results in the tests using pairs of animals. The DD demonstrated lower percentages of socially directed behaviors than the LL, but the LD showed higher percentages. The LD showed more contact behaviors and less positive behavior than did the LL. The LD were less playful than were the LL.

**Results—Postrearing**

**Brief Tests**

**30-hour light.**—Surprisingly, the test using the two groups continuously in the light for 30 hours revealed no significant interactions with group, even though this was the first light social experience for the dark group. The levels of social behavior were surprisingly low throughout this test for both groups, but increased by the time of the baseline measurements for the mixed test several weeks later (see Figure 5).
Fig. 5.—Results of 30-hour and mixed tests for the two groups. Solid symbols indicate those tests occurring in darkness; the Σ indicates the mean of the eight mixed tests only.
30-hour dark.—The test where monkeys remained for 30 hours in the dark in groups of four did differentiate between the two groups. There was also a stable group \( \times \) positive \( \times \) direction \( \times \) time effect, \( F(24,144) = 1.87, p = .013 \). The dark group exhibited more of the two positive behaviors, as can be seen in Figure 5, especially socially directed behaviors, whereas the light group presented relatively more of the two negative behaviors.

Mixed test.—The test designed to accentuate certain behaviors resulted in clear group differences. An overall group \( \times \) test effect, \( F(7,42) = 4.08, p = .002 \), revealed that for most of the tests the light groups showed more of the four behaviors measured. The significant group \( \times \) behavior \( \times \) test interaction, \( F(6,24) = 6.60, p = .01 \), is illustrated in Figure 5. It characterizes the greater play and aggression of the light group in most of the tests. It also illustrates that the dark group were less fearful of visually and auditorily novel inanimate objects but more fearful of strange animals than the light-group.

Preference.—The preference ANOVA revealed no significant effects of groups or lighting condition over the 21 months. Some support for the hypothesis that vision is important in the development of preferences was the tendency for standard deviations to be lowest for the DD in aggression and affiliation behaviors (although the LD was highest in both). Against the hypothesis was the tendency for standard deviations of withdrawal to be highest and of play to be one of the highest in the DD group.

The \( t \)-test comparing the sum of the differences between preference measures in the wedge-cage preference test in the light at 22 months revealed no differences between the two groups (DL-LL) when compared after 1 month of light group housing.

Weight.—The ANCOVA comparing weights of the dark and light groups during the first 240 days of their experimental treatment, while removing the variance resulting from weight just before the experimental treatment was begun, failed to reveal any significant group effects, \( F(1,15) = .08, p = .78 \), or group interactions with age. The dark group was, if anything, slightly heavier than the light group throughout. Not surprisingly, the covariate was a highly significant, \( F(1,5) = 25.11, p = .004 \), source of variance.

Self-aggression.—During the period of the experimental treatment and while housed alone in cages, the dark group were exhibiting on average five times as much self-aggressive behavior as the light group, \( F(1,5) = 8.88, p = .03 \). The difference between the two groups tended to decrease with time as the self-aggressiveness of the dark group decreased in the second test.

The data for the 30-hour tests were also used to test some post hoc comparisons concerning self-aggression. Previous observations (above) when individually housed in cages in the light had characterized the dark group as being more self-aggressive than the light, and group assessment had shown the DD to be less socially aggressive than the LD which, in turn, were less socially aggressive than the LL. It might be that total aggressiveness was equal in these groups, but only the direction differed. Therefore the 30-hour tests were used to compute self-aggression, contact social aggression, and noncontact social aggression (nonsocial aggression was very rare and not included), and the data were compared using ANCOVA with dominance as the covariate and seven repeated tests as correlated variables. As the male was the dominant member in both groups, the covariate was also removing variance due to sex differences. Both dominance rank and sex may have influences on the amount of self-aggression an animal shows (Anderson & Chamove, 1981).

There was no significant group effect, \( F(1,15) = .14, p = .72 \), or group \( \times \) lighting effect, \( F(1,6) = 1.15, p = .32 \), suggesting that when self-aggression was added to the two measures of social aggressiveness at 2 years of age, the dark group were nonsignificantly less aggressive overall than the light group. Whether the monkeys were tested in the light or the dark made no difference to the level of self-aggression they showed. However, the dark group showed twice as much self-aggression as the light group in both conditions. The largest effect was the very high level of noncontact aggression in the dark by the light group.

It should be noted here that, although self-aggression is compared with aggression on the one hand and with other self-directed behaviors on the other, this does not imply that self-aggression is some type or subcategory of, or similar to, other types of aggression (Chamove & Anderson, 1981). There is evidence that self-administered stimulation is quite different from stimulation administered by other individuals (Weiskrantz, Elliott, & Darlington, 1971).

Dominance stability.—Although there was a slight tendency for the D group to be
less stable in both situations, this did not even approach statistical significance in either analysis. The average times to reach 30 and 60 sec of milk drinking in two tests were almost identical for the two groups; the percentage of aggressive plus withdrawal behaviors, which were an inversion from the predicted linear hierarchy, did not significantly differentiate the two groups, group effect $F(1,5) = 1.45, p = .31$, the light group value being about 75% of the overall dark group value.

Fear test.—When comparing fear in the five mixed tests involving high levels of novelty, there was no overall group effect but a highly significant group x test interaction, $F(4,24) = 6.49, p = .001$. It was the intermediate three levels of novelty that differentiated the two groups, with no overlap between these scores in these tests. The light group exhibited three times more withdrawal in the novel room and 10 times more withdrawal toward the strange infant, whereas the dark group showed three times more withdrawal with the novel ticking clock in the dark in comparison with the other group.

Figures 6 and 7 summarize some of the behavioral comparisons between the groups. These pie charts illustrate the percentages of the behaviors included in the comparison and also are made up of percentage data only. Figure 6 presents the behavior x direction interaction during the longitudinal-pairs tests summed over the 21 months. It depicts the relatively higher proportions of aggression and lower proportions of withdrawal in the LL condition. Figure 7 is a descriptive answer to the question, "If we look only at contact social behaviors, will there still be a difference between dark and light conditions?" The pie chart still suggests group differences even when restricting behaviors to those behavior types easily performed in darkness.

Discussion

This study looked at two comparisons. First, behavior of monkeys in the dark given all their social experience in the dark (DD) can be compared with the behavior in the dark of subjects given only some of their social experience in the dark (LD). This comparison enables one to look at the role of vision in the development of social behavior. Second, behavior in the dark can be compared with behavior in the light with the same group of subjects given some of their experience in the dark and some in the light. This LD-LL comparison enables one to look at the role of vision in the expression of social behavior. This latter comparison may also help in the understanding of the short-term handicap nature of blindness.

The major findings of this study were the short-term (during the experimental treatment) and long-term (after the experimental treatment) deficiencies in assertive behaviors, especially aggressive behaviors, in the dark group. A similar short-term difference appeared when comparing the light group when tested in the dark with when tested in the light. The following summarizes the main findings by behavior and type.

Assertive.—The LL group, in comparison with the LD condition and the DD group, showed greater percentages of the two assertive behaviors (play and aggression) and contact assertive behavior early in life, and more socially directed assertive behavior throughout the first 21 months of life. This was also found in the mixed test. This confirms human findings (Imamura, 1965) of half the level of assertive behavior in blind children and may be weak confirmation of reports of the blind being less confident (Petrucci, 1953). This suggests that the development and expression of aggressive behavior somehow depends on, or is influenced by, visual stimuli.

One of the behaviors termed assertive above is play. Play was at a higher level in the controls when in the light than when in the dark in the tests in groups of two and four. However the dark group showed more overall play and more social play in the long 30-hour dark test than the light group. One might attribute this to the dark group being relatively more comfortable in that situation. If the light group were more uncomfortable in the dark than the dark group, then one would expect the LD to emit more withdrawal behavior indicative of increased emotion, but this was not seen in the 30-hour test or in the longitudinal test.

The other assertive behavior, social aggression, was consistently and substantially lower in the dark conditions, confirming prior reports with monkeys (Chamove, 1978). The light group was more aggressive, even in the 30-hour dark test, than the other dark group monkeys. This also confirms reports that the blind are one-third less aggressive than sighted children (Imamura, 1965). The dark group was, however, more self-aggressive than the light group (a) when housed alone, (b) in the 30-hour dark test, and (c) in the 30-hour light test. This, plus a tendency for higher levels of most self-di-
Fig. 6.—The behavior x direction interaction for the 21 months of the pairs test. Hatched segments indicate social direction, the others nonsocial direction (including self-directed).

rected behavior (see Figure 6), may offer tenuous support for reports of Sandler et al. (1965) of the blind being more self-centered and Petrucci (1953) of them being more neurotic and introverted. The consistent findings of lower levels of aggression confirms rodent experiments by Davanzo (1969) that blindness has very basic effects on the induction of aggression.

The dark group were less socially aggressive and received less social aggression when reared with others from their own group. The finding that they were subsequently less socially aggressive after receiving visual social experience is support for the theory of the induction of aggression through the early receipt of aggression (Chamove, 1980); individuals that receive no aggression while young do not become aggressive later on in life. It should be stressed again that these visually socially restricted animals were not like blind children, who may receive aggression from visually normal individuals. The effects of visual social restriction were magnified in this study, where those with such restriction were only allowed to interact with others similarly restricted. When this was done, social aggression was almost never seen; when later allowed to interact socially
Fig. 7.—Pie charts dividing socially directed contact behavior into four subcategories. Withdrawal contact rarely occurred; therefore, it is not included here.
with normal visual input, the level of social aggression remained abnormally low, at a level lower than that of all other monkeys with altered early experience (for a review, see Chamove, 1980).

There were no signs of less stability in the dominance hierarchy or preference abnormalities in the dark group, as suggested by Burlingham (1961) but not confirmed by Imamura (1965) or Fraiberg (1977).

Affiliation.—No clear affiliation differences were found in the 21-month tests. The dark group exhibited more overall affiliation and more socially directed affiliation in the 30-hour dark test. This is some support for Imamura's (1965) finding of more succorance in the blind, but succorance in the monkeys was never the predominant behavior, as has been reported for blind children.

Withdrawal.—This behavior did not reveal group differences in the longitudinal test. The dark group showed less withdrawal in the 30-hour dark test and in the mixed test in the light, which may either reflect emotionality or responses to aggression. Imamura (1965) reports equal levels of submissive behavior in the blind versus sighted children, but Berkson (1977) claims that blindness in free-ranging monkeys primarily increases the level of fear reactions.

The dark group did seem less responsive, especially in levels of withdrawal, to visually novel inanimate objects and were less reactive to the new room and the infant stimulus animal. This supports the finding by Regal et al. (1979), who reported totally dark-reared monkeys being less responsive to visual stimuli. The dark monkeys were more reactive in the presence of novel animals and more reactive toward the unfamiliar ticking clock when tested in the dark.

Direction.—The LL were more socially oriented early in life, but this may be because noncontact social behavior was easier in the light. When compared with the LL, the DD were also less social in the quadruplet longitudinal test, although the LD were more social. This finding is contrary to Imamura's report that the blind interact more with other people. Perhaps as Sandler et al. (1985) suggest, inanimate objects are less interesting to the blind than to sighted individuals.

Behavior type.—The LD showed more contact behaviors than the LL when in groups of four but few other overall differences. On the other hand the LL showed more contact forms of assertive behavior early in life in pairs. This does not confirm the findings of Gergen et al. (1973) of students exhibiting more contact in the dark or of Imamura (1965) of the blind showing equal levels of contact but more noncontact actions than the sighted children.

Behavior rate.—The LL exhibited more overall behavior than the DD at 3 months of age and the light group exhibited more than the dark group in the mixed test. The bout lengths of most behaviors were longer in the LL versus the LD in the longitudinal fours tests. The DD demonstrated longer bouts of contact behaviors than the LL (but the LDs were the longest). This gives some support to Imamura's report that the blind have high rates (short bout lengths) of behavior, especially behaviors he described as succorant and sociable.

One of the most surprising aspects of this study was the speed at which the monkeys adapted to the dark social situation. Within a few days it was impossible to tell whether one was observing in the dark or light situation. In fact the animals seemed so competent in the dark that there was some concern that they could in fact see. They seemed to know where the other animals were even when not in contact with them and even in the more complex group of four. Sitting with the animals in the dark, it was soon evident how this was possible. The animals were making considerable noise breathing. It was likely that the monkeys were using these cues to locate their partners. Whether they could recognize the other animals by these cues was not clear, but when strange animals were introduced into the cage the animals appeared to realize this at once, and their behavior changed from that seen when a familiar peer was introduced. As expected, the dark situation did not appear to be at all aversive to the animals (Chamove, 1978; Weiskrantz & Cowey, 1975).

Another purpose of this study was to observe the development of communicative facial expressions and postures in the monkeys. It should be noted here that there were no differences between the three conditions; in the DD and the LD conditions the individuals showed the normal patterns of gesture, although these gestures could not be seen and/or responded to by the other animals (see Figure 8).

In speculating about the comparisons between monkey and human, we can suggest that the reduced levels of aggressive and assertive behaviors found in those who cannot see result clearly from reduced visual input and that this is in some way cumulative.
Fig. 8.—Four dark group monkeys aged 12 months interacting in total darkness. The figures illustrate the open-mouthed play face with gaze averted (top) and open-mouthed playing while attending to a third animal (bottom).

and leads to an increase in self-directed behaviors. The increased level of succorance in blind children probably results from their disadvantage when interacting with normally sighted individuals and was not found in this experimental study. Of course, there is more to being a blind human than visual deprivation. The cognitive dexterity of the human suggests many caveats when generalizing from a primate model, but the strength of the biological connection between vision and assertiveness seems a provocative one.

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Floor-coverings and Hanging Screens Alter Arboreal Monkey Behavior

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The use of floor-covering has been shown to substantially alter the behavior of captive terrestrial primates. Experiments with two large family groups of common marmosets (Callithrix jacchus) and two of cotton-top tamarins (Saguinus oedipus) have shown that the type of floor-covering also beneficially alters the behavior of arboreal monkeys, increasing use of the floor and decreasing inactivity. These effects increased over 2.5 mo, and appeared to be due to the reduced aversiveness of the floor. Hanging screens also produced beneficial effects.

Key words: enrichment, callitrichid, social behavior

INTRODUCTION

In keeping caged primates, not only should the animals' social and dietary requirements be considered, but the suitability of their environment should also be assessed if abnormal behavior is to be avoided. Since a captive animal is largely free from the threat of predation and the need to search for food, its living area should not only satisfy its physical needs, but should also stimulate the animal and provide opportunities for the time and energy consumption normally pertaining to these aspects of the animal’s survival in the wild. Arboreal monkeys spend between 40% [Marsh, 1981] and 70% [Clutton-Brock, 1977], terrestrial monkeys spend 50% [Harrison, 1983], and chimpanzees spend 74% [Riss and Busse, 1977] of the day in feeding-related activity. The lack of such opportunities has been described as one of the causes of abnormal behavior (ie, stereotypic activity, self-mutilation) in captive animals [Hediger, 1964; Meyer-Holzapfel, 1968]. If stimulus restriction can lead to such dramatic changes in behavior, it is likely that more subtle environmental changes may be reflected in more subtle behavioral changes [Forthman Quick, 1984]. The recognition and documentation of problems that can arise from environmental deficiencies have, in recent years, led to studies both suggesting and evaluating possible solutions.

Answers to these problems are neither obvious nor easy to find since we should not assume that an animal’s environmental preferences will bear any resemblance to

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our own. One primate, the slow loris (Nycticebus coucang), for example, is comfort-
able only when the peat floor of its living space is saturated with urine. When its cage
is cleaned, it will drink large quantities of water to restore its home to this desirable
condition [Hediger, 1964; see also Glatston et al, 1984].

There have been two main approaches to the problem of the enhancement of
 captive existence. The first concerns the environmental aspect of food availability.
Researchers have devised various mechanisms, constructions, and situations that
require the animal to “work” for its food. This work often involves both time and/or
energy consumption and is thus comparable to food acquisition in the wild [Murphy,
1976; Nash, 1982; Markowitz, 1982; Anderson and Chamove, 1984; Chamove et al,
1982; Rosenblum and Smiley, 1984]. The general conclusion from these studies is
that inducing increased effort in food acquisition leads to favorable behavioral conse-
quences, such as reduced aggression and inactivity, and is an efficient way of
improving the quality of captive existence.

The second approach differs from the first in that it tries to achieve an enriched
environment that will provide suitable opportunities for an increased range of the
animal’s natural behavior, rather than seeking behavioral improvement through im-
posed tasks, such as seeking food. Deciding which facets of the environment to
manipulate is difficult in the absence of previous research, since the aim of “suitably
enriching an animal’s environment” is more vague than that of “varying food
availability,” and since what is “suitable” is not obvious. In a very general approach
to this problem, at least two studies have been conducted in which chimpanzees (Pan
troglodytes) exhibiting abnormal behavior were moved from bare laboratories to
more complex, natural settings [Pfeiffer and Koebner, 1978; Clarke et al, 1982]. In
these cases, no single dimension of environmental enrichment was examined, but
rather the effect of a general change of habitat was assessed. Both these studies
showed the move to the more complex environment to be effective in terms of
behavioral consequences. The authors reported a decrease in abnormal behavior (eg,
stereotypic activities) and felt that more complex settings promoted normal behavior
(eg, play and social behavior).

There are at least three studies that have shown the effects of precise manipula-
tion within a restricted environment, and that are particularly relevant to this paper
[Chamove and Anderson, 1979; Chamove et al, 1982; Anderson and Chamove,
1984]. All of these studies looked at the effects of floor-coverings in the cages of
primates under at least three conditions: (1) bare floor (ie, bare concrete), (2) deep
woodchip floor-coverings, and (3) woodchip floor-coverings with food (grain, in-
nsects, or frozen fruit) dispersed through them. Both conditions using floor-coverings
produced favorable effects (eg, less aggression, more play, less affiliation) with the
woodchips plus food condition being the most effective. In addition, these studies
have shown that woodchips do not produce a health risk even when not changed daily
because they actually inhibit the growth of bacteria with time. Additionally, the
presence of woodchips was reported as leading to “less smell, improved appearances”
as well as “an improved cleanliness of the monkeys’ coats, cleaner windows, and
noise attenuation” [Chamove and Anderson, 1979, p 73].

This paper reports an experiment that is an extension of these studies but that
differs in several respects. First, where previous studies have been concerned mainly
with terrestrial primates, here two species of arboreal Callitrichidae were used. In the
laboratory, these species seldom approach the floor when it is bare concrete (ap-
approximately one visit per animal per 25-min session in the baseline of this study); yet field
studies have reported that callitrichid monkeys make regular, functional visits to the forest floor [Neyman, 1980]. *Saguinus geoffroyi*, a species closely related to the *S. oedipus* used in this study, has been observed “crossing grassy, open areas on the ground from one forest patch to another once or twice a day.” Common marmosets, *Callithrix jacchus*, have been recorded as using the ground to “catch insects, to cross forest clearings . . ., and to eat fallen fruit” [Sussman and Kinsey, 1984; p 425]. Izawa reported that black-mantle tamarins (*S. nigricollis*) “rummage in heaps of dead leaves or turn up dead branches on the ground” during grasshopper hunting. During a 7-h observation period he observed an adult male descending to the ground 18 times (total duration 5.3 min). “Tamarins were often observed descending to the ground in search of insects. They usually moved no more than 2–3 m from the tree where they had been. The maximum moving distance on the ground was 12.5 m” (p 248). At times all the members of a group joined an animal on the ground. Thus, it is likely that a cold, wet, concrete floor inhibits behavior on the floor, restricting the animal’s natural behavioral repertoire, and placing additional constraints on the use of the already-limited space available to them. For arboreal animals in captivity, then, the nature of the floor may be a small but important variable.

A second difference between this and previous studies is the choice of floor-coverings used. Only one of the previous studies [Anderson and Chamove, 1984] has briefly compared woodchip with another material, woodwool, which is now difficult to obtain. So in this study woodchips were compared with shredded paper. Lastly, this study measured the long-term effects of floor-coverings by collecting data approximately 2.5 months after the introduction of the floor-coverings.

In addition to extending previous investigations into floor-coverings, this study evaluated the effect of a new environmental stimulus. A hanging screen was designed to visually divide the large housing rooms so that although the visual field was reduced the animals could easily pass through it from one side of the room to the other, and also play on it. There were two main reasons for selecting this particular piece of equipment: (1) it would simulate the natural screening effect of forest foliage, and (2) it seemed that screening might have an effect on levels of aggression. Research has shown that visual restriction reduces aggressive behavior but has less effect on other social behaviors [Berkson and Becker, 1975; Chamove, 1984]. Also, the screen will offer concealment to any individual wishing to avoid an aggressive encounter. We might find that the animals were stressed as a result of the screen being in their room if it disturbed them in some way.

In conclusion, the following predictions were proposed: (1) That arboreal callitrichid monkeys would benefit from the introduction of floor-coverings in the four ways similar to the mainly terrestrial species previously investigated but perhaps to a lesser extent. These are (a) reduced aggression, (b) reduced affiliation, (c) reduced inactivity, and (d) increased time spent on the floor. (2) If the effect of floor-coverings were simply a novelty effect, the long-term floor-covering data would show a trend back to baseline.

**METHODS**

**Subjects**

Four families of callitrichid monkeys, two of common marmosets (*Callithrix jacchus*), and two of cotton-top tamarins (*Saguinus oedipus*), housed in the Stirling University Psychology Primate Unit and habituated to observation, were used as
subjects. With the exception of the adult breeding pairs of tamarins, all subjects were captive-bred and had been living in their rooms for a mean of 30 mo. Data were collected only on independently locomoting individuals, over 2.5 mo of age—46 individuals in all. Family sizes ranged from 8 to 14 excluding dependent offspring.

Each family group occupied a large room approximately $3.2 \times 3.2 \times 3.0$ m, furnished with wooden branches, small cages, swings, and sleeping boxes. On the average, the enclosures had just under 40 linear meters of branches ($n = 15$). If an arbitrary width of .05 m is assigned to each branch, this gives 2.0 square meters of vertical, horizontal, and diagonal branch area, 9.6 square meters of vertical mesh area, 4.0 square meters of horizontal mesh area, and 10.2 square meters of horizontal floor area per family enclosure. Details of the rooms [Chamove, 1981] and animal maintenance [Evans, 1983] are available elsewhere.

**Materials**

In the floor-covering condition, approximately 75 kg of woodchips or 35 kg of shredded paper were evenly spread on the floors of the primate rooms, giving a manipulable substrate approximately 6 and 14 cm deep, respectively. The nature of the two materials made it difficult to equate their different properties.

The screens used in the second phase of the study were constructed so as to visually divide the room in half from back to front but allow animals to pass easily between the two sides. The materials used were 1.7-m lengths of the following: Strips of cotton material 30 cm wide (curtains and bed sheets) both white and patterned, the latter dyed green to reduce the visibility of the pattern; strips of rubber inner tubing; flat strips of black rubber about 7 cm wide; lengths of jute rope; and lengths of plastic garden hose—green, black, and transparent. The lengths of cloth material were attached with staggered 20-cm spaces both sides of a 5-cm-wide metal support so that the screen could not easily be seen through when viewed perpendicularly (see Fig. 1). The remaining materials were attached along the length of the support between the strips of cloth, and the screens were fixed to the ceilings of the animal rooms.

**Procedure**

All observations were made between 1400 and 1700 h on weekdays, with the order of testing balanced to avoid any time-of-day effects. The two manipulations were assessed by recording 4 consecutive days of baseline data and then introducing first the floor-coverings and later the hanging screens, and measuring for each (1) 1 day of novelty effect, (2) then, 1 week later, 6 days of short-term effects, and (3) then, after 2.5 months, 6 days reflecting long-term effects.

Baseline data were collected on 4 consecutive days. Each family was then twice given the “incentive” test, 3 days apart (see below). This test was designed to evaluate how quickly the animals would descend to the floor and to confirm other measures of the floor’s attractiveness. The first administration of this test was to familiarize the animals to the procedure, and the second was to gather data for analysis.

The novelty effect was observed in sessions that began 5 min after the introduction to each family of the floor-coverings or the sessions. One family from each species was given woodchips as floor-covering, and the other was given shredded paper, in order to identify effects that were due to species differences and those that were due to floor-covering differences. One family from each species, each with a different floor-covering, was given a screen.
The short-term data were gathered over a 2-wk period (6 days of testing) starting 6 days after the introduction of the floor-coverings or hanging screens. This interval allowed the novelty effect to attenuate. Following this, the 2-day incentive test was administered once more.

To assess long-term effects, 6 observation days of testing were made approximately 2.5 mo after the initial introduction of both the floor-coverings and the screens.

**Measurements and Behavioral Definitions**

**Visits to the floor.** Each time an animal descended to the floor was recorded for a period of 25 min in each session. Three different measures of behavior on the floor were recorded: (1) *cross*—each time an animal crossed any part of the floor in one complete movement, either walking or running, from one nonfloor location to another. If it stopped on the floor at any point, the whole behavioral sequence was scored in category “stay.” (2) *Fetch* involved only momentary contact with the floor, usually to fetch something on the floor, and did not involve travel across the floor. (3) *Stay* described any time spent on the floor that did not fall into the previous categories, that is, longer and nonlocomotory visits, such as play, forage, or inactivity. This category was judged to be the best indication of attraction to the floor.

At the end of the baseline and floor-covering conditions, food tests were administered to give an additional measure of how much the introduction of floor-covering facilitated the retrieval of highly preferred foods from the floor. A quantity of Farley’s rusk s and green grapes were ostentatiously thrown on the floor, so that one piece of rusk and one grape was offered for each group member. A tape recording served as an 8/s metronome and data collection started as soon as the cage door was shut following delivery of the food. For each animal, the number of the time interval in which they first visited the floor was recorded to give a measure of latency.
To give an approximate measure of *aggregation*, the number of animals in each half of the room was recorded at ten random intervals in each session to see if the screens might alter patterns of aggregation.

The following behaviors were recorded for each animal using focal samples of 30 s, each animal being observed twice in each session.

**Affiliation.** To assess changes in positive social interaction, affiliative behavior was divided into two subcategories. Both active and passive affiliation were scored on a 0 or 1 basis for each 30-s interval of individual observation. Thus, the animal could score a maximum of 2 per session in each of these categories: (1) *active affiliation*, in which the focal animal was involved with another in nonaggressive, physical interaction, eg, sex, play, groom; (2) *inactive affiliation*, in which the focal animal was touching or was within arm’s length of at least one conspecific without overtly interacting.

**Locomotion.** In order to obtain a general measure of movement, gross activity of the focal animal was recorded. Any movement of the animal that was greater than two-thirds of any of the three major cage dimensions (side-to-side, front-to-back, and up-down) was scored. The speed (fast or slow) of the movement was also noted, fast being defined as continuous movement, more rapid than a walk. If, for instance, the animal went from the top back right-hand corner of the room to the top front left-hand corner, it was scored as both a front-to-back movement and a side-to-side movement. It was possible that the screens would alter movement patterns.

**Inactivity.** The animal was timed over all periods of total inactivity in each of the two individual observation periods. Thus, the maximum score for a session was 60 s.

In the baseline of this study, only eight instances of aggression were recorded, approximately one per 50 min. So this behavior was considered too infrequent to be used.

**Analyses**

Four analyses of covariance were performed for each condition comparison, one corresponding to each of the four main behavior categories. The repeated variables corresponded to the four sets of behavioral subcategories mentioned above. Age and sex were used as covariates throughout. The differences between the floor-coverings when using the incentive test were evaluated using a single analysis of covariance.

In analysing the clustering data, the ten repeated measures were treated as a subjects variable, in order to give an estimate of error variance. Three days (first, middle, and last from each condition) were used as repeated measures. As this analysis may not be legitimate, the results were treated as descriptive rather than inferential. The level of significance was set at .01 throughout.

**RESULTS**

Ten weeks after the placement of either floor-coverings or screens, the monkeys showed about 46% less *locomotory* behavior and a reduction of *inactivity* to 67% of baseline levels (see Fig. 2). This was shown by a highly significant main effect of conditions both in the long-term locomotion analysis ($F(2/84) = 21.6, P < .0001$) and in the inactivity analysis ($F(2/84) = 7.95, P = .0007$). The effects of both locomotion and inactivity over the four time periods in the floor-covering analyses
were primarily linear in form (F (1/42) = 18.48, P = .0001 and F (1/42) = 7.90, P = .008, respectively), with locomotion showing a progressive decrease over time with the floor-covering present, and inactivity showing the greatest decrease after 2.5 mo.

The two experimental conditions were found to alter both types of affiliative behavior (see Fig. 3); active affiliation was reduced in the tamarins and increased in the marmosets by a factor of about 2.5 in the long-term in both. This was shown by significant condition × species (P = .002) and condition × species × behavior (F (2/28) = 8.02, P = .0006) effects. Inactive affiliation was at similar levels for both species and increased in the long-term. Active affiliation was initially three times higher in the tamarins than in the marmosets, but changed over the 10 wk period so that both species were at similar levels in the long-term floor-covering and screen conditions.
The floor-coverings increased crossing the floor and long-duration behaviors on the floor by a factor of about 12 compared to the bare-floor condition (see Fig. 4). This was shown by a significant conditions effect (F (2/84) = 23.0, P < .0001), a condition × species effect (P = .003), and a condition × species × behavior effect (F (4/168) = 7.85, P < .0001). Crossing the floor increased more in the marmosets than in the tamarins, “fetch” was not altered by either condition, and “stay” was increased similarly in both species by both floor-coverings (see Table 1). Visits to the floor showed a primarily linear increase with weeks (F (1/42) = 3.76, P < .0001). A weeks × species × behavior interaction (F (6/252) = 3.58, P = .002) reflected the fact that while “fetch” showed no changes over time with the floor-coverings, the marmosets showed much higher rates of visiting the floor in the long-term than in the short-term condition.

The incentive test data showed that the subjects descended to the floor for the desirable and rare rusk and grape more rapidly when the floor was covered (P < .001) and that they went to the floor more rapidly to collect them when paper rather than woodchips was used (P < .01). There was no significant difference in clustering in the different screen conditions, with approximately half of each family on each side of the room at all times.

The covariate of age was highly significant in all analyses (P range = .006 to < .0001), suggesting that different animals of different ages show different levels of the behaviors measured. The covariate of sex was never significant.

**DISCUSSION**

The results clearly showed that the introduction of floor-coverings into the cages of arboreal callitrichid monkeys had positive behavioral consequences. There was a significant increase in the use of the floor area over the first 2 wk, which continued over after 10 wk indicating that: (1) the increased attractiveness of the floor shown in the short-term condition was not simply due to a novelty effect, and that (2) any stress or surprise that the floor-coverings may have caused initially decreased rapidly over time. Previous work suggested that callitrichids were only spending about 1% of their time on the bare floor [Chamove et al, 1982], a surface that makes up about 40% of the total usable surface area and 66% of the horizontal surface area in the enclosure.
It was noted that the animals would not remain on the floor if alarmed, but would immediately leap up into the branches. It may be justifiable to regard the frequency of floor visiting as a roughly inverse measure of stress. In three of the four families, pairs or groups of animals often raced about or playfully wrestled on the floor. The monkeys appeared to enjoy the new media, which made the floors of their cages so much more approachable and usable, and went to the floor 10–15 times more frequently than in baseline. The increased frequency of floor use and the increased speed of food retrieval with floor-coverings indicate that bare floors are aversive to these monkeys.

The remaining cotton-top tamarin family did not increase floor usage and seemed hardly to notice the presence of their shredded paper floor-covering. It was noted that in the three families that did increase floor behavior, the younger and older animals were more hesitant to approach the floor than were the intermediate-aged animals [see also Millar et al, in press]. In the long-term condition, however, the younger and older animals were, in general, making regular, if infrequent, visits to the floor, suggesting that all animals did benefit from the presence of floor-coverings.

There was less locomotory behavior and inactivity the longer the floor-coverings were present, which would seem indicative of a decrease in stress/boredom, but may be influenced by the fact that floor travel requires less energy than travel through trees [Caldecott, 1985]. Thus, since the monkeys were exhibiting less locomotory behavior in the floor-covering condition, and since much of the locomotion in the floor-covering condition that did occur took place on the floor, the animals had relatively more energy to be consumed in nonlocomotory activity than they did in the baseline when the floors were bare.

The majority of the results from the screen condition suggest that it did not cause any stress as the monkeys continued to visit the floor. The positive behavioral effects of the screens were similar to, though less striking than, those of the floor-coverings. The screens were not damaged by the monkeys after 12 months of use.

In conclusion, neither screens nor floor-coverings had stressful events in cages of the marmosets and tamarins, and both conditions led to positive behavioral consequences, the screens to a lesser degree. Floor-coverings opened up a new area for these largely arboreal animals, whereas visual screens had less effect in a species in which aggression is low and group cohesion is high.

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BRIEF COMMUNICATION

Reduced visibility lowers bull aggression

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ABSTRACT

To assess whether reducing visibility would also reduce aggression in farmed bulls, we put 2 newly-formed groups of 20-month old Friesian bulls into two types of paddocks. Those animals in paddocks where visibility was obscured by pine trees showed about one-eighth the level of aggression as those put into a bare grassy paddock. It seems likely that vision is a modifier of aggression in bulls as in some other species.

Keywords: cattle, aggression, enrichment, behaviour, visibility.

INTRODUCTION

A.S. Chamove and B. Grimmer, Reduced visibility lowers bull aggression. Wild cattle live on forest margins where visibility of other animals is less than that common in farm paddocks. The males leave the herd at about 18 months of age to join all-male groups which engage in high levels of aggression for a further 6 months (Squires, 1973). When bulls are farmed in all-male groups, inter-bull aggression leads to damage to both animals and property (Kenny et al., 1987). Two studies (using rats Chamove, 1984; and monkeys McKenzie et al., 1986) have shown that vision is important in maintaining mammalian aggressive behaviour, so, in the absence of relevant research on cattle, we thought that restricting visibility of other bulls might reduce aggression.

METHODS

We observed 2 groups of five 20-month old Friesian bulls just after they were combined into a larger group of 10 bulls following purchase. Animals within the groups of five were presumed, and acted as if they were familiar with one another whereas they were not familiar with those from the other group of five, having been bought on different days. Immediately after putting the two groups together, we put all 10 animals first into a 6 hectare bare grassy paddock for 2 hours (beginning at 1030 hrs in September) and then into a 2.5 hectare grassy paddock planted with unpruned 11-year old radiata pines at 2.7 m spacing (illustrated in Fig. 1) for the same period. All instances of head butting and mounting (Tennessen et al., 1985) were recorded by continuous scan sampling throughout the 4-hour period.

One observer (BG) recorded behaviour by walking within the enclosure a distance from the bulls. Visibility of bulls was clear for about 3 m, at 6 m about one-third of a bull could be seen, while bulls over 13 m could rarely be seen at all.

As soon as the first set of observations were complete, the study was then replicated using different animals (Group 2), but reversing the order of the paddocks. Results were analysed for replications (2 levels), aggressive behaviour pattern (2), and paddock condition (2) using multivariate analysis of variance (MANOVA) with alpha set at 0.05. The single analysis compared the levels of the two aggressive behaviour patterns between the two paddock conditions over the two replications.

FIGURE 1: Four Friesian bulls of a group of 10 in 11-year old pines.

RESULTS

Six bulls showed no aggression and were excluded from the analysis; these 6 were all the objects of aggression by other bulls. A MANOVA of the data from the remaining 14 bulls indicated that the 87% reduction in aggression was highly significant [F (1,12) = 34.0, p < 0.001]. As can be seen in Figure 2, the mean of 4.6 (S.E = 0.57) aggressive episodes per animal per hour in the larger bare paddock reduced to 0.6 (S.E. = 0.18) episodes per animal per hour in the visually obscured...
tree paddock. The effect did not interact with the order of testing or the type of aggressive behaviour shown, and so was independent of these two variables.

FIGURE 2: Frequencies of aggressive butting and mounting by 20 bulls in an open paddock or in a paddock where pine trees visually obscured other bulls.

DISCUSSION

Results suggest that visual cues are important in bull aggression and simple techniques for interfering with these cues can substantially reduce the aggression common when one is forced to mix unfamiliar animals. This is not surprising when farming an animal that in its wild state lives in forest margins where vision is likely to be partially obscured.

It should be noted that both visual and physical access to other bulls was prevented or at least hindered by the trees. In the authors' experience when one animal wishes to assert dominance over another, they will overcome great obstacles to do so; nevertheless, it is possible that the trees were merely making access to other bulls difficult solely by their physical presence. We are presently testing this possibility.

While visibility to the observer was less among the trees, we believe that the levels of aggression there were not underestimated judging from the sounds bulls make when in conflict. We were able to hear interactions much as we could in the bare paddock when these occurred behind the observer.

Behaviour of the bulls towards the observer did not appear to differ between the two conditions; the bulls appeared largely to ignore or simply watch the observer who did not approach the animals.

REFERENCES


Effects of visual cover on farmed red deer behaviour

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Abstract

To assess the effects of visual cover on aggressive and reactive behaviour in female red deer (Cervus elaphus), a single group of 20 hinds was observed over 2 weeks in one paddock, first with no visual cover and then with cover consisting of two barriers made of shade cloth and hanging plastic strips located in one half of the paddock. After replication in a second paddock in reversed order, we found that the provision of cover consistently reduced typical inter-animal aggressive behaviour (to about 60%), and also reduced aggressive behaviour seen during two novelty tests (to about 8-17%). Additionally, the reduced vigilance and grooming behaviour of certain animals and their behaviour during one of the novelty tests reflected, on average, 50% less reactivity with cover nearby. The authors interpret the results to mean that visual cover (e.g. trees planted as shelter) may have additional benefits for red deer beyond that of protection from the elements.

Keywords: Aggression; Cover; Deer; Reactivity; Welfare

1. Introduction

In New Zealand, deer are farmed on open pastures with little or no visual cover, and substantially less than what is available in their natural habitat within forest margins (Chal-lies, 1990). This lack of visual cover may account for Suttie’s (1985) report of over ten times the level of aggression among farmed red deer (Cervus elaphus) than among wild conspecifics.

Research supporting this idea suggests that with visual cover inter-animal aggression is reduced to 13% of that seen without cover in bulls (Chamove and Grimmer, 1993), to 60% in pigs (McGlone and Curtis, 1985) and to about 50-70% in macaque monkeys (Erwin et al., 1976; Estep and Baker, 1991; but see Wilson, 1972, for the situation when the cover prevents control of aggression by the alpha animal).

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Visual cover may also reduce reactivity. Keeping animals in an environment with greater visual cover has been linked to reduced reactivity in mice (Chamove, 1989) and monkeys (McKenzie et al., 1986; Ogden et al., 1991). However, some species (Mongolian gerbils, Clark and Galef, 1977, 1979; antelope, Goldsmith, 1990) raised with visual cover may maintain their natural levels of reactive behaviour.

The present study was undertaken to examine the effects of visual cover on inter-animal aggression and reactivity in farmed red deer hinds. If visual cover has beneficial effects on behaviour then aggression and reactivity should be lower (a) when cover is provided, and (b) when the animals are near the cover.

2. Animals, materials and methods

2.1. Animals and management

The study animals were a group consisting of ten 4-year-old and ten 5-year-old red deer hinds, members of a herd at Massey University deer unit, which had been bred on the farm and reared in grass paddocks with little or no shrubs or trees. All 20 were marked by ear and collar-tags for easy identification. The study was carried out in late winter in two exposed paddocks, rectangular in shape, one 0.5 ha and one 0.7 ha in area.

2.2. Experimental conditions

For the visual cover (VC) condition two visual barriers, approximately 30 m long and 2 m high, were constructed in each paddock by placing seven posts at intervals of approximately 5 m and hanging either solid pieces of black plastic shade cloth or 0.2 m wide strips of black plastic (with gaps of 0.05 m between strips) to a wire stretched along the top and base of each post. The shade cloth made up 60% of each of the 30 m lengths of cover; the strips of plastic and gaps made up the remainder. While the deer were able to pass through the strips of plastic but not able to see through them easily, they could not pass through the shade cloth. A compromise was made between low predator detection and high visual cover by leaving at least one 3 m wide gap mid-way along the length of each barrier. The two barriers were placed in one half of the paddock and were between 10 m and 20 m apart, positioned in an open "V" shape so that the barriers ran in the line of sight from where the observer sat (Fig. 1).

For the bare paddock (BP) condition the barriers were absent in both paddocks. The only object above grass height was a water trough.

2.3. Behavioural observations

Each hind was randomly observed using focal-animal sampling at 8 s intervals, for 2.7 min, during morning (07:30–10:30 h) and afternoon (15:30–17:30 h) sessions. Observations were made outside the paddock from a caravan to which the deer were habituated. The frequencies of the following reactive attributes were recorded: (a) vigilance, i.e. swift raising of the head above the shoulders with ears forward followed by a visual scan of the...
surroundings (Goldsmith, 1990), and (b) self-grooming, i.e. licking the body, or nibbling or scratching the skin. Inter-animal aggression was assessed by recording the frequency of all agonistic behaviour directly involving the focal animal. Aggression included chin lifting and putting back the ears, chasing, stiff kicking with a front leg, and biting (see Thouless, 1990). A new behaviour was scored when the behaviour resumed after stopping for more than 10 s. Additionally, the location of the subject was recorded for each focal animal in terms of the distance from the barriers. It was either (a) far (>3 m from the closest barrier), (b) near (<3 m), or (c) between the two barriers (Fig. 1).

Additionally, in conjunction with and at the same time as focal-animal sampling, behaviour sampling was used to record all instances of aggression, the area it occurred in, and the animals involved. The herd’s dominance hierarchy was found using a standard dominance matrix. Landau’s index of linearity \( h \) was calculated and showed that the hierarchy was strongly linear, \( h = 0.96 \) (Martin and Bateson, 1986).

Aggression and reactivity were also recorded during two novelty tests: (a) an inanimate stimulus was created by placing a plastic 20-l container in the first test paddock, between the barriers (once during each condition); (b) an animate stimulus was designed where a person (with two black dogs) unfamiliar to the deer placed a brown bed-sheet over his head and body and approached the second test paddock, but remained outside, once during each condition. Dogs were familiar to deer, but not the two used here. The dogs remained to the rear of the person and were not threatening in any way. All instances of inter-animal aggression were recorded per minute in both tests. During the animate stimulus test, reactivity was assessed by the time taken for 50% of the herd to react, to move towards the stimulus, and to begin or resume feeding. Fast reaction, slow movement, and slow feeding were taken to reflect increased reactivity (Vandenheede and Bouissou, 1993).

2.4. Procedure

All 20 hinds were exposed to 4 days of each of the two conditions in both paddocks. A 4-day period of habituation preceded each observation. Thus, a repeated measures design
was used. The order of conditions followed a BAAB design where B represents the bare paddock condition. The inanimate stimulus test was conducted in the first paddock, midway through both conditions at the same time of the day. Similarly, the animate stimulus test was conducted mid-way through each condition but in the second paddock. During each stimulus test, behaviour was recorded for a maximum of 30 min.

2.5. Statistical analysis

Separate repeated measures analyses of variance (ANOVA) were performed on the vigilance and grooming data collected during focal-animal sampling. Data were mean scores from the five periods when each hind was observed in each condition, in each paddock. Each ANOVA took the form: dominance (3) × condition (2) × paddock (2). All other data were designed to be descriptive, and therefore were not subjected to inferential analysis.

3. Results and discussion

The results of the daily observations show that when cover was available the greatest reduction in inter-animal aggression, to 58% of the non-cover level, occurred near the visual cover, and consistent reductions appeared in all three locations. Specifically, in the near area (Fig. 1) aggression fell by 42% from 3.20 episodes min⁻¹ in the bare paddock to 1.85 episodes min⁻¹ when visual cover was available. Similarly, aggression fell by 35% from 2.70 to 1.75 episodes min⁻¹ in the between area, and by 28% from 3.45 to 2.50 episodes min⁻¹ in the far area. However, these data were not designed for inferential analysis, but collected to form the dominance hierarchy. Unfortunately, the aggression data designed for inferential analysis (collected during focal-animal sampling) was too low in frequency to analyze: only 0.007 aggression episodes per animal per hour.

Nevertheless, support for a real cover-related effect was provided when the deer were challenged by novelty. When a strange plastic container was put into the paddock (i.e. the inanimate stimulus test), inter-animal aggression fell by 92% from 3.60 episodes min⁻¹ without cover to 0.30 episodes min⁻¹ with cover. Similarly, when a person covered by a sheet walked past the paddock (i.e. the animate stimulus test), aggression fell by 83% from 1.34 to 0.23 episodes min⁻¹.

Reactivity during the animate stimulus test was also affected by visual cover. With cover, the majority of the animals took (a) 34% longer to react by moving away, (b) 50% of the time to begin moving in the direction of the stimulus, and (c) 50% of the time to resume feeding in comparison to their responses in the bare paddock. Further support that cover reduced reactivity can be seen in the levels of vigilance and grooming (Table 1).

With visual cover the vigilance of subordinates was on average 69% of the non-cover level. Likewise, the grooming of dominant deer was just 40% of the non-cover level. Despite the impressive size of the effects, a repeated-measures ANOVA failed to show a significant dominance by cover interaction for either vigilance or grooming (F < 1). Nevertheless, the main effect of cover on grooming approached significance (p = 0.10). Although these effects were nonsignificant, a post-hoc statistical power analysis for a repeated-measures design (Cohen, 1988; Lipsey, 1990) indicated that statistical power was low, making the
Table 1
Reactivity results summarized for each condition by the type of measure for either all 30 deer or only the dominant or subordinate half of the herd.

<table>
<thead>
<tr>
<th></th>
<th>Vigilance * (all)</th>
<th>Grooming * (all)</th>
<th>Vigilance * (subordinates)</th>
<th>Grooming * (dominants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual cover</td>
<td>Mean  0.27</td>
<td>SE  0.04</td>
<td>Mean  0.03</td>
<td>SE  0.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean  0.22</td>
<td>SE  0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.007</td>
</tr>
<tr>
<td>Bare paddock</td>
<td>Mean  0.30</td>
<td>SE  0.04</td>
<td>Mean  0.04</td>
<td>SE  0.009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean  0.32</td>
<td>SE  0.03</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.009</td>
</tr>
</tbody>
</table>

* As measured by the proportion of time observed per animal. SE is standard error of the mean.

nonsignificant results ambiguous. Support for a reliable cover-related effect was seen in the novelty tests, with all three measures of reactivity showing a consistent reduction in reactive behaviour when visual cover was available.

Little is known about the factors that influence aggressive behaviour in farmed livestock. The results reported here provide some support for the work of Chamove and Grimmer (1993), who found that visual cover reduced aggression to 10% of control levels in cattle. In the present study, similar results were seen when the animals were subjected to short-term challenge during the novelty tests, reducing aggression to approximately 10% of that seen in the non-cover condition. Given that the animals used in the present study were female and very docile, as opposed to the bulls used by Chamove and Grimmer, it may be predicted that visual cover would have a greater effect (a) on stressed deer, for example after transportation to an unfamiliar property, and (b) on stags that are, in the authors' experience, more aggressive.

Several factors in the present study may have contributed to an underestimation of the cover effects. First, observations were conducted only when there was sufficient light to identify individual animals. However, it was noted that activity levels were highest at dusk, after data collection had stopped. Second, the cover was designed in such a way as to only partially obscure vision so as (a) not to prevent predator detection (Goldsmith, 1990), and (b) not to obscure the deer from the experimenter. This created the possibility that the cover was not as effective as it might have been simply because there was not enough of it.

In conclusion, it appears that simulated forest cover, providing a reduction in visual stimuli, substantially reduced both inter-animal aggression and reactivity in a herd of red deer hinds. These effects were seen under both normal grazing conditions and in novel situations, the benefits being more dramatic during the latter. These results suggest that when farming deer, visual cover (e.g. trees planted as shelter) may have additional benefits beyond that of protection from the elements.

Acknowledgements

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ment and was approved by the Massey University Animal Ethics Committee; completed in 1993.

References


Part 5: Enrichment--Social

Activity in Humans


Positive short-term effects of activity on behaviour in chronic schizophrenic patients

Arnold S. Chamove

Forty schizophrenic patients were rated both by nurses (using the NOSIE) and by themselves on days soon after they had completed a period of activity. When compared with less active days, significant improvement was seen in most behaviours measured following activity, suggesting that activity is beneficial in the treatment of a population whose level of activity is restricted. Greatest improvement was found in less severely disturbed patients, more overweight individuals, females and those with lower levels of normal activity.

Although there has been increasing interest in the influence of activity on behaviour, research has been almost exclusively on physical as opposed to mental activity [an exception being Lichman & Posner (1983)] and on the long-term effects of regular exercise [exceptions being Timmerman (1954); Clark et al. (1975)]. Reviews of the literature cite consistent effects of moderate levels of physical exercise in reducing depression (Griest et al., 1979; Biglan & Dow, 1981; Blaney, 1981; Antonelli, 1982; Blumenthal et al., 1982; see also Murphy et al., 1972) and anxiety (Vallins, 1966; Morgan, 1976; Greenberg, 1979; Blumenthal et al., 1982; Pauley et al., 1982; Lawrence, 1983; but see Dodson & Mullens, 1969; Morgan, 1974 for long-term effects of regular exercise) and in improving self-concept (Lee, 1957; Nunley, 1965; Layman, 1971; Folkins & Sime, 1981; Lawrence, 1983). The beneficial effects of exercise on the above variables may be partly explained by the fact that exercise is reported to improve sleep (Baekeland, 1970; Morgan, 1976; Oswald, 1982), promote relaxation (DeVries & Adams, 1972; Solomon & Bumpus, 1978; Heide & Borkovec, 1984) [but see Hansen (1976) for exhilaration effects], and improves self-concept (references as above).

Positive effects are quite consistent in the few studies on populations termed geriatric (Clark et al., 1975; Powell, 1975; Folkins & Sime, 1981), mentally handicapped (Nunley, 1965; Oliver, 1971; Collingwood, 1972; Brown, 1977; Bachman & Fuqua, 1983), and where some 'abnormality' is present but is not extreme (Layman, 1974; Poppel, 1980; Black, 1983). High levels of exercise do not have the same effects (Kasch, 1976; Dienstbier, 1981; Frisch, 1984; Harber & Sutton, 1984).

It has long been known that schizophrenic patients score well below normals and below other psychotic patients on several measures related to physical activity and physical fitness (Linton et al., 1934; Hodgdon & Reimer, 1960; Harrington & Cross, 1962; Rosenberg & Rice, 1964; Gordon et al., 1966; Morgan, 1974; Lindquist, 1981), resident schizophrenics being found to be about half as active as non-schizophrenic psychotic residents (Lindquist, 1981). Not surprisingly, long-term patients have been shown to be less active than recent admissions (Rice et al., 1961). One factor which differentiates schizophrenic populations from others is the degree to which they participate in active forms of leisure pursuits (Harrington & Cross, 1962) but not the amount of inactive leisure pursuits (Denney & Myersohn, 1957; Robertson, 1957; Campbell & McCreadie, 1983). Nevertheless, as many as 78 per cent of schizophrenics report that they have used exercise in some way to reduce hallucinations (Falloon & Talbot, 1981). The number of studies on exercise/activity effects in schizophrenia is very low and most of these do not have proper controls, but there is
evidence that it may have the following primarily beneficial effects: increased likelihood of getting a job (Gordon et al., 1966), of coping better (Falloon & Talbot, 1981), of adjustment (Layman, 1971), higher activity level (Clark et al., 1975; Shaver & Scheibe, 1976), increased initiation of social interaction (Chappel & Esser, 1964), and reduced levels of agitation (Timmerman, 1954; Kramer & Bauer, 1955); but possibly increased levels of anxiety and hostility (Dodson & Mullens, 1969).

Several hypotheses were generated from consistent themes in the literature. The few schizophrenic studies suggested that exercise may lead to (1) reduction in disruptive behaviour and (2) increases in activity. Research on other populations indicates that exercise leads to (3) reduction in depression, improvement (4) in mood (especially anxiety), (5) in sleep, and (6) in movement abnormalities, and (7) no change in extraversion or affiliative behaviour. The animal literature suggests that exercise may lead to less (8) time spent in inactivity and (9) negative behaviour (aggression and abnormal behaviours; Chamove et al., 1982). With the exception of the sleep variable, this study assessed whether these categories of behaviour are changed on those days in which schizophrenic patients have previously engaged in some form of exercise.

Method

Subjects

The subjects tested were 40 patients currently diagnosed as long-term schizophrenic by both consultant and senior nursing staff. They came from three wards in Roslynlee Hospital, two wards in the Royal Edinburgh Hospital and the Cambridge Street Day Hostel associated with the latter. The variety of settings was chosen so as to increase the variability in patients, settings, activity opportunities and any reinforcement contingencies that might be present. Table 1 shows characteristics of the five activity groups.

For purposes of analysis the activity groups were arbitrarily combined into two subgroupings here termed physical and mental, each in turn with two levels – low and high. These were designed to characterize the predominant nature of the activity and to further reduce variance in the analysis. All of the women doing keep fit made up the low physical activity–low mental activity subgrouping; men and women doing occupational therapy made up the low physical activity–high mental activity subgrouping; those men swimming made up the high physical activity–low mental activity subgrouping; and men and women doing work therapy and gardening made up the high physical activity–high mental activity subgrouping. There was no attempt to match these activities in other respects and the involvement of both patients and staff in these activities would vary between subjects.

Equipment

The Nurses' Observation Scale for Inpatient Evaluation (NOSIE) was chosen as the main questionnaire instrument for assessment of behavioural change. This 31-item questionnaire has been extensively utilized, evaluated and factor analysed (Philip, 1977; Walls et al., 1977). The following seven factors emerge: social interest, social competence, personal neatness, irritability, manifest psychosis, retardation and depression. Four questions were added to the form used by the nurses reflecting movement disorder, one on initiative, and one on tension (details in Chamove, in press). The nurses filled in the full form of the NOSIE and patients filled in an abbreviated form. For the latter, one question was chosen from each factor, namely, that question with the highest factor loading and rephrased (a) as a question to a patient and (b) to reduce any pejorative connotations.

Seven extra questions were added for the patients to explore other areas of possible behavioural change: two to assess tension and one each to measure pleasure, arousal, competence, group membership and general well-being (details in Chamove, in press). These 13 extra questions were derived from the results of various factor analyses in other areas of behaviour (e.g. White, 1959; Chamove et al., 1972; Paul, 1977; Canter & Craik, 1981). Personal neatness was not of interest and was therefore not analysed.

The hypotheses of this study were tested as follows. Changes in activity as a result of exercise were assessed by using the NOSIE retardation items (three nurse-rated, one self-rated). Disruptive behaviour was evaluated using the NOSIE social competence (five nurse, one self-rated) and NOSIE
Table 1. Composition of each of the activity groups and mean values of the covariates for males and females

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Years in hospital</th>
<th>Age</th>
<th>Overweight (%)</th>
<th>Daily activity (cal)</th>
<th>Increased activity (cal)</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>Keep fit</td>
<td>0</td>
<td>8</td>
<td>25</td>
<td>61</td>
<td>14</td>
<td>267</td>
<td>222</td>
</tr>
<tr>
<td>Occupational therapy</td>
<td>5</td>
<td>6</td>
<td>27</td>
<td>64</td>
<td>2</td>
<td>447</td>
<td>174</td>
</tr>
<tr>
<td>Work therapy</td>
<td>5</td>
<td>5</td>
<td>12</td>
<td>50</td>
<td>2</td>
<td>486</td>
<td>1336</td>
</tr>
<tr>
<td>Gardening</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>46</td>
<td>5</td>
<td>492</td>
<td>1152</td>
</tr>
<tr>
<td>Swimming</td>
<td>5</td>
<td>0</td>
<td>29</td>
<td>2</td>
<td>930</td>
<td>740</td>
<td>40</td>
</tr>
<tr>
<td>Mean</td>
<td>16</td>
<td>51</td>
<td>7</td>
<td>378</td>
<td>670</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>17</td>
<td>17</td>
<td>14</td>
<td>436</td>
<td>515</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>2-53</td>
<td>20-77</td>
<td>-11-40</td>
<td>0-1720</td>
<td>100-2400</td>
<td>10-70</td>
<td></td>
</tr>
</tbody>
</table>

*Calorie expenditure (see text).
irritability (four nurse, one self-rated) items. Depression was assessed using the NOSIE depression items (four nurse, one self-rated). Affiliation was tested by the NOSIE social interest items (five nurse, one self-rated). Negative behaviour was evaluated by means of the NOSIE psychosis items (four nurse, one self-rated). Coordination used the four movement disorder items (nurse-rated), and tension utilized the three tension items (one nurse, two self-rated).

Procedure

This study was designed to look at short-term changes in schizophrenics, comparing behaviour after varying amounts and types of activity. Constraints prohibited the imposing of activities so use was made of normal variations in the opportunity for activity and variability in the degree of energy expenditure by the different patient groups. Those activities chosen by patients were influenced by two factors: subject choice and the activities offered by the ward where individuals were resident.

Before the study was begun, all subjects were approached, and an explanation of what was needed was given, although not of the purpose of the study. Patients were advised that they might withdraw their consent at any time during the study (Zangwill, 1973). Two subjects took advantage of this and withdrew during the study; none of their data were used in the analysis. The purpose of the study was described to both patients and nurses as one designed to look at the variation in behaviour and mood on different days of the week. Therefore both the patients and the nurses were rating blindly. For five subjects it was not possible to prevent the nurse raters from knowing the true purpose of the study. Anyone with a condition which would disqualify them for sports participation according to the Committee on the Medical Aspects of Sports (Allman, 1974, p. 102) was not included; these were quite serious conditions and in fact only one person was so disqualified.

All OT/activity/exercise sessions were rated for at least two days and most (70 per cent) for four days. All activity sessions were compared with data collected over a period of at least two days and most (70 per cent) for four days when the activity did not happen. Consequently, behaviour could be compared on at least two days when the exercise did not take place with behaviour in the same subjects on at least two days when it did take place. Four subjects could only be rated on one day for one of the conditions. We tried to avoid, whenever possible, active days being weekdays when inactive days were weekends because of other possible differences between activities during these two types of days, but for six patients this was not possible as their work therapy occupied all five of the weekdays.

The ratings were done as close to two hours after the exercise as possible, but no sooner, and at least two hours after meals (see Linton et al., 1934). The 36-item nurse questionnaire was filled out first by one nurse, and then the 13-item self-rating of the patients was completed. The latter was presented to the subject by a different nurse, preferably and usually on a different day. These raters were consistent throughout testing so as to reduce within-subject variance on repeated measures as much as possible, and nurse and patient scores were rated separately so that nurse questionnaire ratings were not influenced by the subject's self-reports. For six subjects the two ratings within a condition were done by different raters on the two days.

Covariates. As the length of hospitalization has been shown to affect both behaviour and response to exercise (Folkins, 1976; Kielhofner et al., 1983), this variable was recorded as duration of the present hospitalization and used as the first covariate in the analyses. Also recorded was the subject's age (Folkins, 1976), height, weight, level of medication, an estimate of degree of pathology (Collingwood & Willett, 1971), and an estimate of the amount of physical exercise normally taken by the subject. The last was made by nurses and converted into calorie expenditure estimates from standard tables (Tarnower, 1978). This was done to estimate level of initial fitness, which also has been shown to be important in response to exercise (Folkins & Sime, 1981). The estimate of severity/pathology was made by the consultant on a 0–70 scale. Both estimates were made just before the data recording was begun. The level of psychotropic medication was converted to equivalent potency units of chlorpromazine for statistical purposes. This was done by estimating their effectiveness as dopamine receptor blocking agents (Seeman, 1981; Kendall & Zealley, 1983). The weight and height information was converted to 'percentage overweight' (Stock & Rothwell, 1982; Black, 1983) using standard tables (Metropolitan Life Insurance Co., 1972). The resulting data for the subjects used are summarized in Table 1. As can be seen from this table, certain of these factors were distributed differently over the different groups, namely ages ($F = 6.62, d.f. = 6, 29, P = 0.0002$), normal physical exercise level ($F = 3.25, P = 0.01$), and level of the additional physical exercise ($F = 10.26$, $P = 0.0002$).
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$P < 0.0001$), with older patients involved in less physical activity. These six factors were used as covariates so as to reduce any variance due to these variables.

Prior to analysis all scores on checksheets were converted so that a high number indicated a negative or unhealthy response. The items in each of the seven NOSIE factors were combined to reduce the number of items and to increase the stability of the scores (Krauth, 1983). The same was done for the four movement disorder items and for the two self-report items concerned with tension.

Analyses. The first stage of analysis involved two large analyses of covariance (ANCOVA) to answer the questions: were there overall effects of activity (a) on the nurse or self-rating scales of the NOSIE, or (b) on the other more global self-rated measures? The first analysis was a groups physical $(2) \times$ groups mental $(2) \times$ activity $(2) \times$ rater $(2) \times$ measures $(6)$ with six covariates where the last three factors were repeated measures. Covariates for these analyses were sex, severity, weight, medication, normal exercise and additional exercise. The second analysis was of the form groups physical $\times$ groups mental $\times$ activity $\times$ measures with six covariates where the last two factors were repeated measures.

The second step involved a more detailed analysis after a significant effect in the overall ANCOVA or where a priori comparisons were indicated (Brown & Tinsley, 1983). For the NOSIE data these five were disruption, depression, activity, psychosis and affiliation; for the other data two a priori comparisons were for tension and movement disorder. ANCOVAs (Snedecor & Cochran, 1967) were run using the BMDP statistical package (Dixon, 1981).

The third step was to convert all scores to change scores reflecting the mean of the actual effects of activity (non-activity minus activity means) and a Pearson product moment correlation coefficient was computed between these difference scores and all of the covariates. Three new variables were also formed combining all NOSIE scores, all NOSIE nurse scores, and all NOSIE self-rated scores.

Results

The results indicated that all the patients were rated better on all of the NOSIE measures on activity days in comparison with less active days. The overall analysis of covariance on all six NOSIE scores taken over two raters and over the two activity conditions showed one significant result related to activity—the overall activity effect $(F = 10.31, \text{d.f.} = 1,30, P = 0.003)$. This result was taken as justification for looking at the NOSIE data in more detail. The overall ANCOVA of the other six global scoring categories gave no significant interaction with activity and so no further analyses of these categories were undertaken. Overall activity effects were found upon subsequent analysis of five of the eight categories concerned with the hypotheses. Significant improvements resulted from ratings of disruption $(F = 9.29, P = 0.004)$, movement disorder $(F = 4.65, P = 0.038)$, depression $(F = 4.79, P = 0.030)$, retardation $(F = 4.38, P = 0.04)$, and tension $(F = 15.71, P = 0.0004)$.

Figure 1 shows the results summarizing all subsequent analyses giving the activity by rater interaction for all categories. These are reported below; all $F$ values have d.f. $= 1,30$.

Interactions of activity with rater were found in two of the analyses. Manifest psychosis showed an improvement on the nurse ratings $(F = 4.85, P = 0.034)$ but a slight deterioration when self-rated. Similarly, in the social interest category there was a greater improvement in the nurse rating than when patients rated themselves $(F = 6.98, P = 0.01)$.

Interactions of activity with physical activity were only significant in one analysis. This interaction in the analysis of disruption scores suggested that the group with the lower levels of physical activity showed more improvement than those with higher levels $(F = 6.28, P = 0.017)$. The depression interaction was suggestive $(P = 0.06)$; again lower levels of physical activity tended to show greater improvement with activity than did higher levels.

One interaction of activity with mental activity was suggestive $(P = 0.054)$, indicating that a higher level of mental effort might lead to greater improvement in psychotic symptoms (also Attkisson & Anker, 1970). In the tension analysis there was a tendency for
both of the group factors to interact with activity \((P = 0.051)\), suggesting that the greatest improvement in tension after activity might be in the low mental–high physical activity grouping and the least improvement in the high mental–high physical activity grouping, with the two low physical activity groups intermediate.

The covariates of medication level and normal activity level were both significant factors in the initial overall analysis using the NOSIE scores, while the number of years in hospital was significant in the initial analysis using the more global measures. In the subsequent analyses sex was a significant covariate for disruption, movement disorder, social interest and depression. Medication level was a significant variable for manifest psychosis, severity for movement disorder and normal activity level for retardation.

A Pearson correlation coefficient was computed between all covariates and all eight of the hypothesis variables, using 'change from no activity to activity' scores as data. The combined variables were also used here. Two partial correlation coefficients were also computed, the first removing variance due to normal level of physical exercise, the second partialing out the amount of additional physical exercise level on active days. The partial coefficients are only reported below when they improved the results from the simple correlations.

Greater improvement as a result of activity was found in the analysis of additional activity levels \((r = +0.41, P = 0.01)\) and in the nurse ratings of movement disorder \((r = +0.34, P = 0.03)\) in more overweight patients. Greater improvement in depression scores after activity was associated with lower severity of illness ratings \((r = -0.35, P = 0.04)\) and the correlation became even stronger when controlling for normal and for

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**Figure 1.** Significant within-subject difference scores on eight categories showing low activity minus high activity days; positive values indicate improvement. Shaded bars are from the NOSIE; bars with circles depict self-ratings and those without circles are nurse ratings.
additional exercise \( (r = -0.39 \text{ and } -0.40, \text{ respectively}) \). There were no significant associations for tension, affiliation or psychosis scores, although the last tended to be improved more in more active people after partialling out normal exercise level \((r = +0.33, P = 0.05)\). The only other category to show associations was ‘feels worse’, and here improvement on active days was correlated with high medication levels \((r = +0.43, P = 0.007)\) and with more sedentary patterns \((r = -0.34, P = 0.04)\). When looking at the larger aggregates of scores, there was more improvement in NOSIE nurse ratings in those who were more overweight \((r = +0.35, P = 0.04)\). Greater improvements in NOSIE self-ratings were found in females \((r = +0.42, P = 0.01)\) and in less severely rated patients \((r = -0.34, P = 0.03)\). Similar results were found when using all NOSIE ratings—more improvement in females \((r = +0.44, P = 0.005)\) and in less severe patients \((r = -0.36, P = 0.03)\). In addition, improvement in this score was associated with being more overweight \((r = +0.40, P = 0.01)\).

**Discussion**

Results have shown that when long-term schizophrenic patients were rated on days when they were relatively more active and compared with ratings on days when they were less active – both by nurses or by themselves using the NOSIE rating scale – almost all categories showed a significant improvement on more active days. Patients showed significantly less psychotic features, less movement disorder, were less irritable, less depressed, less retarded, less tense, and showed more social interest and more social competence. Correlations and partial correlations controlling for both normal levels of physical exercise and level of exercise of the most active days, indicated that the greatest improvement was found in less severely disturbed patients, in more overweight individuals, in females and in more sedentary patients, and perhaps in those with only moderate increases in exercise. All of these correlations were supported by the literature using other populations except for the greater sensitivity of females to the beneficial effects of activity.

The predictions from the long-term effects of activity on behaviour were largely supported by the short-term effects found here. Although small, the consistently beneficial effects of activity in a population where behavioural treatment has not been promising suggest a direction for interventions in this difficult patient group. This is not to suggest that inactivity is the cause of their illness, simply that altering their behaviour towards more activity improves it. There is the possibility that occupational therapy and work therapy have benefits not recognized before.

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**References**


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Exercise Improves Behaviour: A Rationale for Occupational Therapy

by Arnold S Chamove, MPhil, PhD
Clinical Psychologist, Stirling University, Scotland

A theoretical position accounting for the short-term effectiveness of occupational therapy is proposed, based on the sociobiological position that humans need exercise/activity. Predictions were evaluated using several forms of occupational therapy with long-term schizophrenic patients. Most areas of behaviour measured were improved on those days on which occupational therapy was included.

INTRODUCTION

Although there has been increasing interest in the influence of exercise on behaviour, research has centred almost exclusively on the long-term effects of regular exercise (exceptions being Clark et al.1 and Timmerman2). Reviews of the literature cite consistent effects of moderate levels of physical exercise in reducing depression4,5 and anxiety,6 and in improving self-concept.7 The fact that exercise is reported to improve sleep8 and promote relaxation9 may explain some of these results. Positive effects of exercise are quite consistent in the few studies on populations termed geriatric10 and mentally handicapped,11 and where some 'abnormality' is present but is not extreme.12

The theoretical basis for exercise/activity effects on behaviour is not convincing. Occupational therapists who advocate the use of physical activity in the treatment of psychiatric problems cite no theoretical rationale for its use (for example, Macdonald13 and Mosley14) but in some reports there appears to be an underlying assumption, characterized as a 'sense of mastery'15 or 'self-esteem'.16

Based on the effective use of physical exercise in the treatment of anxiety states, psychologists have suggested that exercise changes feedback information that often leads to increases in anxiety as a consequence of perception of rapid heart rate which occurs in stressful situations. The reinterpretation of sympathetic nervous system information after exercise leads to long-term reduction of the negative feedback loop. This idea has been elaborated into a more general cognitive model of adaptation and emotion17 which includes the learning and use of coping strategies and the development of competence.18

One prediction of such a model would be that training in any skill, physical or mental, would have general effects on all behaviours influenced by a person's concept of competence. However, this appears to be the case only within mentally handicapped populations15,16 and is definitely less so in other populations studied where improvement is restricted to the practised modality (for example, Smith and Figetakis19).

I would like to suggest another theoretical basis: an evolutionary or a sociobiological model. This explanatory position, based on the theory that there is a strong biological predisposition to certain activities, would suggest that humans have evolved in such a way that certain behaviours are more probable than others in certain settings. When these behaviours are prevented, abnormal behaviours must take their place. As an example, given that individuals are biologically programmed to spend a large proportion of the day working, when this activity is prevented a large proportion of the day is occupied with behaviours that normally happen less frequently or not at all. This is the situation the occupational therapist normally confronts.

To compute a 'natural' level of activity, a sociobiologist would look at tribes of hunter-gatherers, assuming that these people would best reflect behaviour patterns throughout much of recent human evolution. When this is done, there is evidence that, in the average day, women carry the equivalent of 25 kg over a minimum of 7 miles for a minimum of 3 hours (my calculations from Blumkon Jones and Sibly20). More data are available for energy budgets of nonhuman primates showing that monkeys spend over 50% of the day active21 and chimpanzees are active for over 75% of the day.22

When activity is reduced in animals, for example in captivity where the opportunity for travelling is restricted by caging or the opportunity for foraging reduced by feeding all their food ration at once, then abnormal behaviours are changed. An implication of abnormality is that abnormal behaviours are the result,23 such as increases in aggression, self-aggression and stereotypes. In one study using eight different monkey species, simply reinstating the opportunity to search for woodchips for food led to a reduction in aggression to 10% of previous levels, decrease of other 'undesirable' behaviours by 80%, and 42% less time spent inactive.24 Even when given continuous free access to the same foods, the monkeys chose to work by foraging.25 As self-injurious behaviour may be partly caused by the restriction of activities in both humans26 and monkeys,27 allowing opportunities for activities reduces self-injurious behaviours in both species.26,27

It has long been known that schizophrenic patients score well below normals and below other psychotic patients on several measures related to physical activity and physical fitness, resident schizophrenics being found to be about half as active as nonpsychotic psychotic patients.28 Nevertheless, many schizophrenics report that they use exercise in some way to reduce hallucinations.29 The number of studies on exercise effects in schizophrenia is very low but there is evidence that it may have the following primarily beneficial effects: increased likelihood of getting a job,30 coping better,31 adjustment,32 higher activity levels and reduced agitation,20 but also increasing levels of anxiety and hostility.31

Several hypotheses were generated from consistencies in a review of the literature. The few schizophrenic studies suggest that exercise leads to (1) reduction in disruptive behaviour and (2) possible increases in activity. The research on other populations suggests that exercise leads to (3) reduction in depression, (4) improvement in mood (especially anxiety), (5) improvement in sleep, (6) improvement in movement abnormalities and (7) no change in extraversion or affiliative behaviour. The animal literature suggests that exercise may lead to (8) less time spent in immobility and (9) less negative behaviour (aggression and abnormal behaviours). With the exception of the sleep variable, this study will assess whether these categories of behaviour are changed on those days on which schizophrenic patients have previously engaged in some form of occupational therapy.
METHOD

The patients tested were 36 people who were diagnosed as long-term schizophrenics by both consultant and nursing staff from three wards in Roslynelee Hospital, two wards in the Royal Edinburgh Hospital, and the Cambridge Street Day Hostel associated with the latter. The major question of interest was as follows: When comparing activity days with nonactivity days, are there differences between various behaviour categories in the amount or direction of change shown? A second question of interest was: Does the effect of exercise depend on the type of exercise in question?

To answer the latter, the exercise experience of the 36 patients was classified into five categories.
1. The first was composed of six females involved in mild keep fit exercises lasting 15–30 minutes or walks of less than 1 hour in duration. This category was believed to include mild physical exercise and little or no mental activity such as problem solving or decision making.
2. Another category of three males and six females involved occupational therapy of 1–2 hours and included procedures such as baking, art therapy, quiz games and communication sessions. This category was conceptualized as low in physical exercise but relatively high in mental activity.
3. Work therapy involved five males and five females in 2–5 hours of activities such as working in a laundry and building picture frames. It was believed to include moderate levels of both physical activity and mental activity.
4. Gardening involved six males in about 5 hours of moderate gardening work, with above-moderate levels of both physical and mental activity.
5. Swimming involved recreational swimming for five males for about 2 hours once a week, conceptualized as high physical activity but low mental activity. In this last subgroup only, all patients had substantial amounts of work offered on nonexercise days, involving work therapy such as working in a print room or carpentry, and including amounts of physical activity that were almost double those of the nearest other group and were significantly greater than those of the other groups (p = 0.01).

The Nurses' Observation Scale for Inpatient Evaluation (NOSIE) was chosen as the main questionnaire instrument for assessment of behavioural change. This 31-item questionnaire has been extensively utilized, evaluated and factor analyzed. The following seven factors emerge: social interest, social competence, personal neatness, irritability, manifest psychosis, retardation and depression. A rater ticks one of the following: never, sometimes, often, usually or always, coded 1–5. Four questionnaires were added to the nurses' form reflecting movement disorder severity (range on a 0–10 scale) and the subjects' ratings of anxiety (range on a 0–10 scale). The nurses filled in the full form of the NOSIE and the patients filled in an abbreviated form. For the latter, one question was chosen from each factor. Two extra questions were added for the patients to assess tension (Appendix 1).

The hypotheses of this study were tested as follows. Changes in activity were assessed by using the three retardation items; disruptive behaviour by the five social competence items and two irritability items; depression by the four depression items; affiliation by the five social interest items; mood by the five social interest items and the two anxiety measures; and negative behaviour by the five irritability, four psychosis and four movement-disorder items. Since most were assessed by self-ratings as well, these were used in the hypothesis testing. The main analyses of covariance tested the hypotheses described above. All involved the seven groups; all had the basic form of a groups (7) × exercise (inactive vs active days) × measures × rater (nurse rating vs self-rating).

Prior to analysis, all scores on check sheets were converted so that a high number indicated a negative or an unhealthy response. The items in each of the seven NOSIE factors were combined in order to reduce the total number of items and to increase the stability of the scores. The same was done for the four movement disorder items and for items recording tension and heart rate in the self-reports.

The purpose of the study was described to both patients and nurses as to look at the variation in behaviour and mood on different days of the week. Therefore, both the patients and the nurses were rating blindly. For five subjects, it was not possible to prevent the nurse raters from knowing the true purpose of the study.

Constraints prohibited the imposing of additional exercise so use was made of the normal variations in the opportunity for activity and variability in the degree of energy expenditure by the different patient groups. Most occupational therapy/activity/exercise sessions were rated for 4 days; most activity sessions were compared with data collected over a period of 4 days when the activity did not happen. By randomizing the day of beginning data collection, there was a countering of the order of recording from activity and nonactivity days. Consequently, behaviour could be compared on about 4 days when the exercise did not occur with at least 2 days on which it did.

The ratings were done at least as close to 2 hours after the exercise as possible and at least 2 hours after meals. The nurse questionnaire was filled out first by one nurse and then the self-rating of the patients, the latter being presented to the subject by a different nurse and usually on a different day.

Covariates: As the length of hospitalization has been shown to affect both behaviour and response to exercise, and patients were hospitalised for periods that were not statistically equivalent so that these differences would be eliminated. Covariance was chosen. Length of hospitalization was recorded as duration of the present hospitalization and used as the first covariate in the analyses. Also recorded was the subject's age, height, weight, level of medication, an estimate of the degree of pathology, and an estimate of the amount of physical exercise normally taken by the subject (Table 1). The last was made by nurses and converted into calorie expenditure estimates from standard tables. This was done to estimate level of initial fitness, which also has been shown to be important in response to exercise. The estimate of current severity of pathology was made by the consultant on a 0–70 scale. The level of psychotropic medication was converted to equivalent potency units of chlorpromazine for statistical purposes. This was done by estimating their effectiveness as dopamine receptor blocking agents. The weight and height information was converted to 'percentage overweight', also using standard tables.

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RESULTS

The results indicated that most variables measured (73%) showed improvement on those days during which activity levels were higher in comparison with less active days, and the overall amount of improvement was also greater than that of deteriorations.

An overall analysis of covariance (ANCOVA), comparing the seven groups on the two exercise conditions over all measures (covariates), showed that there were highly significant effects of exercise (p = 0.004) and exercise interactions with both measures (p<0.0001) and with measures and groups (p = 0.002). Alpha for all comparisons was set at 0.025.

The first two subsequent analyses evaluating specific hypotheses were on activity and depression behaviour but no significant effects of interest were forthcoming in either (p = 0.04, p = 0.03), although the trend was for improvement in both.

Significant effects related to exercise were found in the remaining four ANCOVAs. The highest order significant
interaction for each significant effect is depicted in Fig. 1. Here scores are plotted in terms of change after exercise, a positive score indicating improvement in the behavioural category. The first hypothesis showing significant exercise effects was that of disruptive behaviour. The overall exercise effect (p = 0.003) indicates that exercise was of benefit to all groups. The interaction (group x rater x measure x exercise [p = 0.024]) plotted in Fig.1, shows that the first two sub-measures at least (nurse-rated social competence and nurse-rated irritable) consistently improved with exercise, the third (self-rated social competence, column three) appears to improve primarily for females, and the fourth (self-rated irritable) appears to deteriorate for many of the groups and most markedly for males.

The second significant ANCOVA is that using affiliative behaviours. Exercise x rater (p = 0.001) and groups x rater x exercise effects (p = 0.004) were both significant and the latter are shown in Fig.1. As can be seen, the first measure (nurse-rated social interest) shows consistent improvement in most groups on exercise days.

The third ANCOVA tested the negative behaviour hypothesis (groups x measures x exercise, p = 0.021). As the effect of rater was not significant, it is not included in Fig.1. The first component of this category (nurse-rated irritable plus self-rated irritable) appears to be consistently improved with exercise, while the other two (nurse-rated plus self-rated manifest psychosis and nurse-rated movement disorder) are more variable over the different groups. Level of medication was found to be an important covariate in this analysis, suggesting that medication alters the degree to which exercise affects negative behaviour.

Finally, the mood category led to significant effects (exercise effect, p = 0.005; rater x measures x exercise interaction, p = 0.005). As these did not interact with group, the main effect of exercise is presented in Fig.1 (lower right), averaging over all seven groups. The illustration shows the clear improvement in nurse-rated social interest (left) and an even larger improvement in self-rated 'tense' (right).

**DISCUSSION**

The results show that when long-term schizophrenic patients were blindly rated on days on which they were relatively more active and the ratings were compared with those on days on which they were less active, either by nurses or by themselves using the OBS measurement scale, almost all categories showed some improvement on the more active days. Patients showed significant improvements in social competence, irritability, social interest, tension/anxiety, movement disorder and psychotic behaviour. Although activity level also increased, this was not significant.

The predictions from the long-term effects of exercise on behaviour were largely supported by the short-term effects found here. The effects reported here are not large, but they are consistent and are almost uniformly positive when stable. Because of the nature of the assessment, it is unlikely that the effects were a result of or an artefact of the intervention; it is also unlikely that the positive effects were a result of self-selection, that is, subjects choosing to be more active on those days on which they felt better. Although small, the consistently beneficial effects of activity in a population where behavioural treatment has not been promising suggest a direction for interventions in this difficult patient group. This study suggests that occupational therapy and work therapy have short-term benefits not described before.

It is interesting that variability in the energy expenditure of the various tasks used did not lead to consistent and obvious differences in effects. Many of the behaviours measured were affected differently by the different tasks and had different effects in males and females.

The use of occupational therapy in psychiatric illness has been based upon both the studies of the use of occupational therapy in physical injury and the belief that normalization is beneficial. The psychological literature suggests another ration-

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**Fig. 1.** Significant effects of exercise with males in the left column and females in the right column. The five exercise categories were keep fit, occupational therapy, work therapy, gardening and swimming. For each of the negative, affiliative and disruptive behaviours, the nurse-rated categories are shown on the left and the self-rated on the right when there were significant effects of raters. Hatched histograms indicate improvement, clear indicate deterioration.

The three measures of negative behaviour shown are (left to right): nurse-rated irritable + self-rated irritable; nurse-rated + self-rated manifest psychosis; and nurse-rated movement disorder.

The two measures of affiliative behaviour are (left to right): nurse-rated social interest and self-rated social interest.

The four measures of disruptive behaviour are (left to right): nurse-rated social competence; self-rated irritable; self-rated social competence; and self-rated irritable.

In the mood category, the two measures showing improvement are nurse-rated social interest (left) and self-rated 'tense' (right).
Appendix 1. Extra questions to the NOSIE

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<tr>
<td>Behaviour patterns are disordered?</td>
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<td>Appears tense?</td>
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</table>

<table>
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<tr>
<th>Self-rated</th>
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<tr>
<td>Do you feel tense?</td>
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<tr>
<td>Does your heart-beat feel fast?</td>
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</table>

References

Health Visitor 1989; 42: 301-302

Summary

Using a medical, social, and functional assessment form, we found several measures which were reliably associated with a criterion of impending mortality. Activities of daily living were most highly correlated, medical assessment and services needed were correlated less strongly, but visual impairment and the cumulative total of all measures were the best predictors (r = .42).

Introduction

Most research projects involving health visitors and the elderly involve screening, and almost all of them are concerned with either assessing what facilities or services the elderly want, or need, or use. The question of evaluating the effectiveness of the intervention is rarely asked or answered. Perhaps this is because of the difficulty of finding criterion scores which can tell us whether what we do really works. The easy way to evaluate services is to ask the professional, but more objective ways are desirable.

A number of surveillance studies have shown usefulness in the management of patients and the ability of health visitors to spot areas of potential danger for the elderly. Such a scheme was devised and is being operated by the general practitioners and health visitors within the Viewfield Medical Centre. Described in detail elsewhere, evaluation has so far consisted of summary scores which targets those medically at risk and those in high need of support (35%). Those so identified are given a high input of services and aids to partially anticipate demand and continuous assessment to record change. While we do not yet have sufficient data to evaluate client outcome and the process of care, we have collected enough to see which measures are associated with imminent death and with improvement in activities of daily living.

Method

Since 1986 Viewfield Medical Centre has routinely collected data on 1100 patients aged over 70 years, a group known to have a high

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FIGURE 1: Correlations of categories with mortality. Negative correlations are indicated by a minus sign after the name.
level of physical impairment. As shown in figure 1, the data was divided into three categories: services needed by the patient — 10 subdivisions listed as present or not; medical assessment — 10 subdivisions rated 0 to 6; and activities of daily living — 13 subdivisions rated 0 to 5. Totals of each of the three categories were also calculated as was the cumulative total of all scores. The scores were used to compute a change score from the previous six-month assessment. These change scores might indicate impending deterioration if high or the value of increased services if lowered. The categories and subdivisions are listed in figure 1 and a high number in any category indicates morbidity.

For this evaluation, all of those dead (n = 25) and all in long stay hospital (n = 4) were selected. A random selection of those not dead or in hospital was chosen as a comparison (n = 77). Ages ranged from 73 years to 88 years. Individuals were rated as either 1 — living at home, 2 — living in hospital, or 3 — dead. This number was then correlated with the numbers obtained from the three categories of assessment to see which were better predictors of mortality.

A "Pearson product moment correlation" was used, tests were two-tailed, and alpha was set at 5 per cent. When it was found that many of the variables correlated with age and we wanted the correlation of all the variables independent of age, a partial correlation was carried out partialling out the effects of age. For this partial correlation a coefficient of .20 is significant at p<.05 (.25 for p<.01). The results for this correlation independent of age are presented in figure 1.

Results
As illustrated in figure 1, for services needed (bottom) the requirement for the district nurse and the other services of the social work department were the two variables significantly correlated with mortality, after effects of age had been removed. In the medical assessment category (middle) problems concerning the cardiovascular system (especially in males), memory, locomotor, and endocrine systems were the four that were reliably associated with death independent of age.

In the ratings of activities of daily living (top), seven subcategories were significantly associated with mortality: visual impairment, restricted mobility, poor personal hygiene, dietary deficiency, lack of household independence, and weight extremes (being overweight or obese) were all rated more highly on assessments prior to death. These subcategories were all better signals than the deterioration score for either category; only deterioration in the daily living score approached a significance in its correlation with impending death. Deterioration in the medical assessment and improvement in the daily living score were most strongly associated with the presence of a home help (r = .26) and emergency care (r = .21). Weight extremes led to the greatest deterioration in the daily living score (r = .24).

The total scores for each of the three categories of assessment were good predictors of subsequent death, and the cumulative total was one of the two best predictors (r = .42, p<.0001). A step-wise multiple regression suggested that emergency care was the best variable to add to the cumulative total to improve prediction, and this increased the correlation with mortality to .60; note that the presence of emergency care, a negative correlation, is not seen in those who subsequently die.

Discussion
This evaluation exercise has identified several attributes which appear more strongly connected with subsequent mortality than others, namely problems with vision, hygiene, and mobility. Irrespective of age, in our population, needs and problems in these areas are seen more consistently in those who die within six months. It was clear that most of our categories were correlated with one another, suggesting that problems in one led to problems and needs in others. It is now possible to alter services to this subgroup to preclude deterioration in this group that is clearly at risk.

Whether vision was so important because it has such close connections with the nervous system, because it is such a psychologically important sense, or because it limits independence is not clear. It is likely that many of the problems areas lead also to reduction of self-esteem, perceptions of self-control, competence, and asertiveness. This suggests that some systemic surveillance would be of use to arrest a cycle of deterioration.

Like other studies which have set objective criteria for evaluation, the objectively-assessed benefits are less striking than the opinions of professionals or patients about "quality of life". This may be because quality is primarily what we have to offer, or it may be because the health we tender is so difficult to measure.

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Intrinsic interest of objects for elderly people in long-stay mental handicap hospitals

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When 97 elderly people with mental handicaps were observed on three long-stay hospital wards, it was found that objects on the wards were used more if they were personal possessions, especially by the women. Manipulability of objects for women and sociability of objects for men also increased object interest. Most (60 per cent) of the 522 objects on the wards were never seen to be used.

One salient phenomenon of people on long-stay wards is their extensive inactivity (Jenkins et al., 1977). This inactivity has been termed "disengagement" behaviour and is associated with: low morale, self-esteem, and happiness; badly functioning respiratory and circulatory systems; irregular elimination; and muscle atrophy (wasting) (Comstock, Mayer's, and Folsom, 1969; Maddox and Eisdorfer, 1962). Any reduction in disengagement as a result of activity programmes seems to occur only during the programme sessions, and it is likely that the absence of interesting items or desirable facilities at other times is the factor responsible for inactivity (Jenkins et al., 1977; Keilhofner, 1966). Moving people from an institution to small, community-based residential homes with more facilities has been found to lead to a 65 per cent increase in the use of furniture for between 22 and 40 per cent of the day time (Felce et al., 1985).

Objects are put on wards to interest and involve the people living in them. Two items that have been investigated are television and windows. Prior research in hospitals has concluded that elderly people are the greatest users of television, those who are least active using it the most (Young, 1979). Rooms with windows have been described as more friendly and interesting (Kaye and Murray, 1982), a "better" view may aid recovery from surgery (Ulrich, 1984), and people seem to prefer views of activity to those of natural scenes (Verderber, 1986).

No research literature on the use of other objects by people restricted to wards through mental handicap or age has been traced although relevant research on animals restricted in a similar manner has been carried out (Chamove, in press). The study that will now be described attempts to determine the intrinsic interest of common objects for elderly people with mental handicaps living on long-stay hospital wards, to see which objects are used and which intrinsic object characteristics influence their use.

Method

The 97 elderly people studied were residents of a large hospital housing individuals of all ages with handicaps and mental illnesses. They were chosen from three wards, each of which was in a separate building. None had been classified as having mental illness. Most had been classified as having mental handicaps, but a few had been committed as being unable to care for themselves some time ago. Ward F housed 23 women in an old, listed building with beautifully carved walls, carpeted floors, and old fireplaces in excellent condition; it had 285 objects, comprising 22 different categories. Ward M housed 38 men in an old, purpose-built building with a bare interior and linoleum-covered floor; in it were 126 objects of 19 different types. Ward MF housed 20 men and 10 women and was a modern ward with carpet and a "pleasant" interior; it contained 111 objects of 22 types.

The mean age of the people studied was 68 years (range 40 to 90), and the mean length of hospitalisation was 43 years (range 3 to 75). Five people were blind, six did not walk, and 18 were epileptic. When asked, only one person indicated a wish to be excluded from the study, and did not take part.

The objects considered were all items which it was thought were included in the wards for the use of the people living there. These ranged from the obvious, such as personal stereos, pianos, magazines, and television, to less obvious objects, such as windows, plants, lamps, pictures, wall ornaments, and a canary. Each object was ranked, using a seven point scale, as to its position on six categories which were thought likely to influence intrinsic interest:

- personal: the extent to which a particular object belonged to an individual who controlled its use (personal stereo = high, piano = low);
- variability: the amount the content of an object could change (photograph = low, television = high);
- predictability: the amount of uncertainty in the performance of an object (wall ornament = low, view from window = high);
- activity: the amount of movement needed in order to use an object (stereo = low, knitting = high);

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manipulability: the amount the form of an object can be altered (picture = low, jigsaw = high); sociability: the amount of social contact involved in using an object (reading = low, dominoes = high).

Data were collected by one observer (KM), who sat in a corner of the social area of each of the wards. A tape recorder acted as a metronome, sounding a tone every 10 seconds. Data were collected as instantaneous samples, that is, were recorded at the sound of the tone, at which time the observer noted who was using which object. "Using" included looking at objects. People were given time to become used to the observer's presence for two days, and data were then collected for three days between 09.00 and 17.00 hours. Data collection was discontinued when there were changes in routine, such as occupational therapy.

It was, of course, difficult to be certain when people were using objects which required no obvious action on their behalf (discussed in Ulrich, 1984: Young, 1979). For some, TV for example, head orientation only was regarded as indicative of use. For others, such as stereo, observations of orientation were confirmed by other behaviour, such as rhythmic movements while apparently listening.

For analysis, three adjustments were made to the scores. Those took into account:

- the number of people present in the room during data collection;
- the number of people who could simultaneously use an object; and,
- the amount of data collected on each person.

Only one person owned a crochet hook and therefore the maximum number of people who could use it at any one time was one. Correlations were carried out between the percentage of time the objects were used by the available population and the ranking of each object on each of the six interest categories. Pearson Product Moment correlation coefficients were calculated.

Results

The most popular objects were stereo players (in use 50 per cent of the time for the available population) and the television (in use 20 per cent of the time for the available population). As many as 60 per cent of available objects were never observed in use at all. Windows with a lovely view onto woods, for example, were never seen to be used.

When the percentage of object use was correlated with the ranking of the objects on the six interest categories, objects rated as personal were used more than those rated less personal on all three wards (men r = +.34; women r = +.66). When these correlations were re-run with this category partitioned out, the only remaining significant correlation was with manipulability (r = −.30), suggesting that less manipulable objects were used more. The reason for this was the high use of television and stereo which had low manipulability ratings. When these two objects were removed from analysis in a subsequent comparison, the partial correlation coefficient changed to a significant r = +.27, suggesting that other highly manipulable objects were used more.

The only other suggestive correlation was a positive correlation between object use and the sociability rating of objects for both men and women (r = +.49 and +.24 respectively) in the mixed-sex ward, but low correlations in the other two wards. Could it be that sociability is maintained at a higher level in mixed wards?

Discussion

The most consistent result was that elderly people with mental handicaps in long-stay wards use personal objects more than objects with other characteristics. All 17 personal objects present on the wards in this study were used, and a personal type of object was the most popular on every ward. On Ward F, where a newspaper was a personal object purchased for one of the residents, it was the fifth most popular object; whereas in Ward M, where a newspaper was present for all to use, it was never seen to be used.

The personal category was not as important for men as for women. This may be because the men had less than half the number of personal objects than the women. Also, men used objects less than half as much as women, a significant difference (p < 0.05). It is possible that personal objects may be given to or encouraged more in people whom staff consider are most likely to make use of them, but in this study many of these items were purchased or requested by the elderly people themselves or given to them by relatives.

Clearly, research of this type is relevant for those who are involved in choosing objects to purchase for long-stay wards housing people with mental handicaps. A study in which objects are brought onto a ward in a controlled way is necessary if the present findings are to be confirmed or extended.

Acknowledgements

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SECTION A: EXERCISE AND MENTAL HEALTH IN PSYCHIATRIC AND NON-PSYCHIATRIC POPULATIONS

EXERCISE EFFECTS IN PSYCHIATRIC POPULATIONS: A REVIEW

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This introduction will review the literature on the effects of activity on behaviour in order to explain exercise effects in psychiatric populations. It looks at the effects of (a) moderate increases in physical activity, (b) extreme increases in physical activity, and (c) the deprivation or restriction of physical activity on behaviour. Most of these studies are from the sports literature as studies in other areas are uncommon. We shall look at three types of research: (a) the most common correlational studies, (b) quasi-experimental studies, and will concentrate on (c) the most powerful but least frequently reported type of investigation - experimental studies. Finally, we shall look at the psychiatric patient in an attempt to predict how this population might be idiosyncratic in its response to activity.

Moderate levels of physical activity

When added to an individual's normal activity level, moderate increases of brief bouts of exercise have been shown to lead to very different effects from experiments using sustained levels of physical activity, especially when measuring mood. At least two studies have found that brief exercise bouts did not influence reported levels of anxiety, although in both, the subjects did report "feeling better" after the exercise (Morgan, 1974b). Subsequently Morgan (1976) reported that 30 minutes of walking led to lowered anxiety.

Greenberg (1979) found that running 12 miles significantly reduced both trait anxiety (a general feeling) and reduced state anxiety (a present feeling), although the latter only to a lesser extent (also Pauly et al, 1982). The greatest decrease was found in high trait-anxious individuals, especially males; and superior athletes are sometimes characterized by high trait anxiety (Martens, 1974). This result has recently been replicated where 10 weeks of jogging reduced both trait and state anxiety, tension, depression, and fatigue in comparison to a sedentary comparison group who chose not to exercise (Blumenthal et al, 1982).

Response to stress

Much research shows that moderate exercise (eg jogging) leads to a reduced stress response to a wide variety of subsequently introduced stressors, such as cold or loud noises (Carruthers, 1978; depending on how stress is defined, Chaimers, 1981). It is interesting that higher levels of activity, like

**Mental vs physical**

Exercise often has a physical and a mental component. Few studies have attempted to separate the effects of the two. Lichtman and Posner (1983) have been one of the few to compare the effects of physical with mental activity (their "controls") on both mood and cognitive function. Here 32 normal individuals chose to do a physical activity (jogging) and 32 chose a mental activity (a hobby) to do twice a week. Testing occurred before and once immediately after one of the sessions. The Stroop Color and Word Test was given to 30% of the subjects. The subject is asked to name the colour or read the word in a list of words (eg the word "green" written in red). Significant interactions on both the word sheet and colour sheet of the Stroop were found between groups and pre-post effects. Cognitive function increased in the physical exercise group as assessed by both of these sub-tests but not in the mental exercise group. The results of the two self-administered mood check-lists are more difficult to interpret as (a) the results of one did not always agree with the other, and (b) a large number of analyses of variance (ANOVAs) were used, followed by an even larger number of pre-post t-tests for each sub-scale and for each sub-group, applied irrespective of the results of the ANOVAs; and the more powerful error term from the ANOVA was not used. Nevertheless, the results suggest to this reader that (1) scoring on a tension-anxiety sub-scale may be reduced by both physical and mental exercise, (2) depression was reduced by physical and "perhaps" (one test significant after a significant ANOVA) by mental exercise, and (3) fatigue was (and perhaps anger, concentration, and unpleasantness were) reduced by physical exercise. It should be noted here that the two groups also differed on pre-test measures (also Hellison, 1970): those who chose to do physical exercise were initially less depressed, less angry, but more tense. Higdon too (1978) had a mental exercise (hobby) control group but found physical exercise only reduced reports of "stress".

More indirect evidence for exercise benefits come from a study where children either walked or travelled to school by bus. While longer travel distances were associated with poorer social and emotion adjustment scores as rated by teachers, those who went by bus were rated less well adjusted than those walking the same distance. There was no effect of age of the child, but boys were more adversely influenced by the bus than were girls (Lee, 1957).

**Time-out**

More recently there have been comparisons of exercise with other time-consuming but non-physical activities. Comparisons of exercise with meditation have found both to be equally effective in reducing anxiety levels (Bahrke and Morgan, 1981). This suggests that in much of the exercise
research the period of the exercise may be equivalent to a "time out" period from daily activities and may not be unique to physical activity at all. The finding that exercise-breaks during physical work leads to improved performance on a number of measures (Donoghue, 1977), suggests that the beneficial effects of exercise may not be restricted to an output of energy, but may be due to exercise functioning as (1) merely a change in behaviour, or (2) a distraction or diversion from other events (Greist et al., 1979; Morgan, 1979). Muscle massage also has been reported to reduce anxiety (McKechnie, Wilson, Watson and Scott, 1983).

Relaxation

Yet another possibility is that the short-term (ie. within the day) after-effects of exercise are like relaxation in that both have been shown to lead to reductions in autonomic nervous system activity and reductions in muscle tension. The post-exercise period may even help to produce the four factors posited to improve relaxation, namely consistent stimuli for attentional focusing, a passive attitude, comfortable posture and minimal muscular effort, and a quiet, non-distracting environment (Benson, 1974). A direct comparison of exercise with the muscle relaxant meprobamate showed exercise to have significantly greater effects on resting musculature (DeVries and Adams, 1972).

Although the general reported response to exercise is relaxation, exhilaration effects may also occur both during and after exercise. When observing boys playing baseball, telemetered heart rate when "at bat" was especially high, increasing by about 60 beats/minute from pre-game levels. One-third of parents stated that their children were too excited to eat normally after a baseball game (Hansen, 1976).

But if exercise is in some way like relaxation, then it may have some of the drawbacks too. If so, then one might expect effects similar to "relaxation-induced anxiety", when relaxation initiates or exacerbates anxiety in certain individuals, as reported for both relaxation training and meditation (Heide and Borkovec, 1984). It seems that individuals are particularly prone to relaxation-induced anxiety if their anxiety is pervasive or generalized. The above authors hypothesize that these individuals may (a) need to remain in control, (b) believe that active effort is important in achieving self-control, and (c) are likely to be persons who avoid inactivity. The extent to which psychotic individuals fit 'a' and 'b' is not known, but they could hardly be described as avoiding overt physical inactivity - what Fogle refers to as "learned restlessness" (1978). It seems that exercise-induced relaxation would meet the conditions of 'b' and 'c' at least, if not also of 'a' (see Martens, 1974) and therefore might be a way of inducing relaxation in these difficult patients.

Perhaps biofeedback would too. One study at least has shown better control of frontalis muscle tension during exercise periods than outside periods of exercise (Kirkcaldy and Christen, 1981). It seems that exercise is not a direct, deliberate method of relaxation, but may be an indirect result of active effort.
Heart rate has been believed for a long time to be an index of anxiety. A review of the classical aversive conditioning literature suggests that this is not strictly the case. Fowles (1982) concluded that heart rate seems rather to be an index of activity of striate musculature, which in turn may reflect anxiety. As such, heart rate is not a reliable indicator of anxiety states (Obrist, 1981). Increases in heart rate are caused by a variety of stimuli; increased somatic activity, active withdrawal, and approach to a food reward (Gray, 1978).

Nevertheless a person's bodily responses have been found to be an important determinant of behaviour (Schachter and Singer, 1967), and heart rate is one of these.

It may be that individuals interpret their own heart rate as an index of anxiety or arousal. This has been clearly shown, for when false heart rate feedback was given to subjects, their affective ratings of Playboy centrefolds was altered, the effect being greatest in more emotional subjects (Valins, 1966). In individuals trained to accelerate or decelerate their heart rate, acceleration was associated with increased arguments and reduced attitude change when presented with a "disagreeable" message (Cacioppo et al, 1973). Experiments altering heart rate using cardiac pace-makers led to changes in behaviour even when subjects were unaware of the changes in heart rate (Cacioppo and Petty, 1976). It is also possible to train individuals to control (reduce) heart rate and blood pressure during exercise (Johnston and Lo, 1983).

**Exercise as stress**

Are adult psychiatric population the correct age to benefit from exercise? If we view exercise as a beneficial stressor, then this literature is relevant. The animal literature confirms the idea that an optimal level of stress leads to an increase in an individual's adaptive responsiveness to stress. The early work of Denenberg (eg 1967) showed that mild stressors applied daily to young rodents produced increased adrenal capacity and a less reactive temperament in adulthood. As stressors become more prolonged (Konecni, 1975; Ottinger, Denenberg and Stephens, 1963) or more intense (Candland et al, 1977; Chamove, 1980b), subjects often become more responsive to stressors, although curious temporal anomalies were reported (Denenberg, 1967; Ryan and Wehmer, 1975). From the animal research, several lines of evidence suggest that greater sympathetic nervous system (SNS) capacity and hormonal capacity are associated with more positive responsiveness towards stressful situations, with temperaments characterized by less anxiety and emotional reactivity (Candland et al, 1977; Chamove and Bowman, 1976; Michael, 1957).

However, the few human studies on this subject do not support the same conclusion. As an example, students with high cold tolerance indicating high SNS response capacity rated themselves as more fearful, more "emotionally controlling", but as having a higher preference for emotional and suspenseful entertainment (Dienstbier, 1981).
Certainly stressors applied early in life are more potent in their effects (eg Denenberg, 1967; Hess, 1959), but it seems that more sustained stressors applied during adulthood are able to influence at least some of the same mechanisms as neonatal stressors. Because the response to exercise and to physical and psychological stressors is so similar, and since regular exposure to physical stressors leads to increased stress tolerance, one might infer a similar connection for regular exercise (Michael, 1957). Therefore, it has been suggested that exercise increases the size, and lowers the threshold of stimulation, of the adrenal cortex resulting in increased reserves of anti-stress steroids and faster response times to stressors (eg Candland et al, 1977). Others have gone even further, speculating that "it was our assumption that the high heritability of temperament dimensions such as emotionality and activity existed because these physical dimensions depend, in part, upon physical predispositions such as those associated with the SNS and related hormonal capacities" (Dienstbier, 1981, p 196).

One might predict that if one could alter SNS and/or hormonal responsiveness, then one could alter those temperament dimensions referred to above. On the other hand, it may be that physiological changes are appraised differently after a programme of exercise, which in turn leads to more controlled changes of these physiological responses (Folkins and Amsterdam, 1977). The fit jogger's heart responds differently towards experimentally imposed psychological stressors - with increased stroke volume rather than with increased rate (Chapman and Mitchell, 1965).

**Aggressive behaviour**

The relation between sports and delinquency seems mostly to have been researched by Schafer (eg 1972). His publications suggest that participation in sports is only associated with lowered levels of delinquency in populations in which delinquency is at its highest, that is in low socio-economic groups. The explanatory theory of 'control' seems best able to explain results in this area (Purdy and Richard, 1983). It has been consistently shown that athletic groups are less "sportsman-like" than non-participant groups (Stevenson, 1975). Participants in competitive sports are more aggressive both during and after the event (Gelfand and Hartman, 1976, also see Lefebvre et al, 1981). For example, over 90% of the interactions of 11-year old boys were classified as friendly, but that figure decreased to only 10% after a competitive game when 40% were unfriendly.

When looking at the integration of racial groups, two large studies were able to produce no evidence of group participation in sports leading to increased or improved interactions across races (Stevenson, 1975). Unfortunately, the studies have not looked at the details involved in instructions to the participants, to interactions within the groups, or to other cognitive variables known to affect group cohesion, alliances, and identification.
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HIGH LEVELS OF PHYSICAL ACTIVITY

High levels of exercise are commonly studied in two contexts: (a) the immediate effects of high levels of physical activity on behavioural and physiological changes during and soon after these events, and (b) the long-term effects of "fitness", that is, effects of chronic high levels of physical activity on behaviour and physiology measured well after the activity events, (e.g. even 6-10 years after, Kasch, 1976).

Fitness

Fitness is believed to be healthy and some believe "should be included as a basic element in appropriate, preventive, and corrective medical ... care" (AMA, 1974, p 32; Heaps, 1978; Murphy et al, 1972). There is general agreement that fitness includes components of the following: motor fitness, physical working capacity, body weight, relaxation, flexibility (Ryan, 1974a), and perhaps also elements of balance, endurance, power, strength, and agility (Mathews, 1963).

Physiological changes

Some of the relevant research uses a within-subjects design where behaviour is compared both before and during activity. Athletes in training are the most commonly used subjects and results show the following physiological changes after periods of physical activity: improved breathing efficiency including the use of additional abdominal and neck muscles, increased blood volume and haemoglobin concentration, increased heart stroke volume due to enlargement of chambers of the heart, increased numbers of mitochondria in individual muscle cells (Ryan, 1974a), increasing strength of connective tissue (Bouth and Gould, 1975) and decreased electrical activity in muscles, especially in more anxious subjects (DeVries, 1968). Also during both short-term high intensity and prolonged low intensity exercise, increases in superficial vasodilation (up to seven times, Andersen et al, 1971) and in epinephrine and norepinephrine secretion were reported. It is noteworthy that in moderate exercise, only blood levels of norepinephrine were increased whereas in mild exercise neither of the catecholamines was increased at all (Riggs, 1981). From the vasodilation results above, it is not surprising that brief vigorous exercise has been reported to control headaches (Atkinson, 1977), although no comparison groups were used in that study.

A high level of exercise may also have detrimental sequellae: it can be accompanied by critically low levels of blood sugar, low arterial levels of oxygen, increased brain temperature (Powell, 1975), altered hormonal cycles independent of weight (Frisch, 1984), and inefficient cardiac responses (Dempsey et al, 1982).

Opiates

Distance runners who have been running regularly long distances for an extended period of time excrete endorphins which may lead to the release of
brain serotonin, especially in the limbic system (Kolata, 1979; Riggs, 1981; Solomon, 1980). These opiates may influence the physiological changes reported (Harber and Sutton, 1984). In a review of the dozen or so studies of endorphins and exercise reported between 1981 and 1983, the authors state that few firm conclusions can be drawn. They note that whereas under 50% of subjects show opioid increases with an 'easy' run, 80% show increases after a 'strenuous' run. They also note opioid connections with menstrual changes (Harber and Sutton, 1984). There are equivocal reports showing increases in blood dopamine, growth hormones, prolactin, and serotonin with exercise (Riggs, 1981). It seems that in this case the technique of investigating high extremes of exercise to exaggerate effects, in fact leads to different conclusions from studies of moderate or low levels of exercise.

Subject selection

The most commonly-published research, unfortunately confounding selection procedures with the manipulation studied, compares samples of athletes with non-athletes; and uses only male subjects (Allman, 1974a). There are also many studies which compare winning athletes with losing athletes. The differences in these two groups are too subtle to be of interest in this paper, and also, many of the studies find no differences between the two groups. This is not surprising as it is unlikely that losers plan or train to lose; loss is only evident at the end of contest. It is important to distinguish studies of team sports from those of individual sports as a higher incidence of introversion and depression-like responses have been elicited in several studies of individual sports participants (Folkins and Weiselberg-Bell, 1981; Morgan, 1974a).

Depression

Another confounded effect of subject selection is the higher than expected prevalence of primary affective disorder in runners, especially in female runners (Colt and Dunner, 1981). It is therefore curious that exercise should be suggested as a treatment for depression. Nevertheless, two recent studies have done just that and found that 10-12 weeks of running exercise led to improvement in mildly depressed patients (Blaney, 1981; Greist et al, 1979; see also Murphy et al, 1972). Greist assigned patients randomly to either individual exercise conditions (running) or an unspecified "individual psychotherapy" condition. No discussion of depression was rewarded or encouraged in the exercise group. Two unsupported comments are of interest:

"Depressive cognitions and affect seldom emerge during running and when they do, they are virtually impossible to maintain. The technique of concentrating on separate physical elements of running (ie., breathing, sound and feel of foot falls, awareness of erect spine position) was successful in breaking through depressive ruminations in all ... patients" (p 45). Drop out was only 11%. Finally, deprivation of exercise in 'exercise addicts' led to an increase in depression scores (Thaxton, 1982), but controls were not used.
There are several older studies of the effects of exercise on depression (Morgan, 1969). One suggestion as to their efficacy is that exercise is a way of increasing the number of pleasant events, or the number of activities an individual is doing (Biglan and Dow 1981; Ferster, 1981; Simpson et al, 1981). If this is the case, then one would expect exercise to be more effective and more preferred than activity, ineffective or detrimental if not a preferred activity, and no more effective in altering depression than equally preferred sedentary activities (Lewinsohn, 1975). It has also been claimed (Post et al, 1973) that certain biochemical changes in clinical depression are secondary to changes in physical activity.

The connection between exercise and norepinephrine and between norepinephrine and depression (Stone, 1983) would be suggestive if it could be clearly demonstrated. When asking depressed patients to simulate the activity of mania, Post et al recorded increased cerebrospinal fluid concentrations of the major central metabolite of serotonin, 5-hydroxydoleacetic acid; metabolites of dopamine and norepinephrine were elevated too. They reported that "most patients experienced some mood elevation during the procedure" (1973, p 70). In addition to suggestions of serotonin changes with exercise, there are also indications that manipulations of serotonin lead to changes in aggressive behaviour, both short-term (Brody, 1970; Dichiara et al, 1971; Matte and Tornow, 1978; Redmond et al, 1971) and long-term (Chamove, 1980a; Chamove et al, 1970; excellently reviewed in Vorhees et al, 1981); and in self aggression too (Cataldo and Harris, 1982). It may be simplistic, but this suggests that one might expect exercise to affect levels of aggressive behaviour. It has also been reported that severely depressed patients may be characterized by high muscular tension levels (Watmore and Ellis, 1959). Abnormalities of muscle structure have been reported in schizophrenics too (Meltzer and Engel, 1970), and exercise has its effects on musculature.

Since running has a putative antidepressant effect, it is possible that the individual suffering from depression gravitates towards running as self-treatment. Some work using monkeys suggests a link between activity and depression. Harlow (1971) noted that after separation from an attachment figure, young monkeys underwent three stages of behavioural change, the first of which was termed "protest" and was accompanied by above normal levels of activity; the second was similar to human depression. When he separated monkeys and simultaneously restricted the possibility of any locomotor activity, he found an exaggerated intensity and duration of this depressive-like behaviour, as if exercise helped in certain stress situations. In rats too, physical restraint exacerbates the effects of stressors (Archer, 1979).

**Personality**

When comparing the personality of athletes with non-athletes, several differences have been found. The athletes seem to have greater stability (versus anxious) scores, and greater extraversion (versus introversion) scores. They also tend to have higher aggressiveness and need-achievement
responses. The athletes report greater pain tolerance, judge pain as less intense, and judge time as passing more slowly (Cooper, 1969; Ismail and Trachtman, 1973; Morgan, 1974a; Smolev, 1976). Of 18 studies which attempted to compare personality characteristics of groups which differed in either athletic abilities or participation, 11 of those studies found no differences in personality; and of the seven which did find differences, few were consistent in their findings.

Kane (1970) could discover no discriminant space between the personality profiles of either male or female participants taken before and after a three year physical education course but there were suggestions that champion athletes may be more self-assured (Kane, 1971). Studies of participants in team sports versus individual sports give equivocal results too, but there was some support for the idea that team sports may be associated with extraversion and low self-sufficiency (Stevenson, 1975) and individual sports with an increased frequency of depressive responses (Morgan, 1974b). Morgan (1976) concluded that physical exercise may effect the day-to-day state-dependent mood but it is unlikely to alter the long term trait-dependent personality.

Socialization

Stevenson concluded, after an excellent critical review of the literature, that because of methodological confounding and contradictions in results, "there is no valid evidence that participation in sport causes any verifiable socialization effects" (1975, p 287); but the measures used to assess socialization were on the whole indirect and very gross ones. Eight studies showed that academic performance was increased in athletes versus non participants, and a further two studies showed general cognitive performance was increased in athletes versus non-participants, and a further two studies showed general cognitive performance improvement during the season in comparison with off-season testing (Folkins and Sime, 1981; also Powell, 1975).

Dropout

There is some evidence that individuals who are not stable extraverts drop out of sport at a greater rate (Ryan, 1974a). Dropouts from exercise therapy after myocardial infarct were more depressed, anxious, and introverted than those that continued, independent of physical state (Williams et al, 1982). Dropout is a substantial problem in exercise research; 30%-70% of individuals drop out after three-six months and 90% after one year (Martin and Dubbert, 1982). In attempts to predict adherence to exercise regimes, the best indicators seem to be a combination of self motivation scores used in conjunction with measures of body fat and body weight (Dishman, 1981; Dishman et al, 1980; Yaffe, 1983). Adherence can be modified behaviourally (King and Frederiksen, 1984).
Expectation

The relevance of another possible confounding variable may be questioned. Dienstbier (1981) found that the expectations about the effect of exercise do not match any real changes in personality, so the few changes reported in personality were not due to the expectancies of the subjects. This variable is usually neither measured nor controlled for in exercise studies. Several studies (Ismail and Young, 1973; Morgan and Roberts, 1970) on the duration of exercise suggest that the 10 weeks of exercise used as a minimal level in so many studies may not be long enough to change stable traits such as personality, but those stressing an interactional view of personality might question this restriction (Mischel, 1981).

Twin-studies identify many inherited differences in activity related physiology (Bouchard and Lortie, 1984), but it should be especially noted that they also show that there are substantial differences in the latency of physiological changes in response to exercise (Folkins, Lynch and Gardner, 1972). Here predictions based on behavioural feedback theories would differ from those of sociobiologists, the former stressing long-term changes and the latter expecting short-term modifications resulting from exercise.

So it seems that in the study of exercise, randomization of groups is especially important, and when it is not done, there are strong measurement effects due to self-selection. Individuals heavily committed to running even report that their sport is more important to them as part of how they wish to be viewed by others than is their job (Joseph and Robbins, 1981). Little (1969) found that although athletes used the Harvard Psychiatric Services less frequently than non-athletes, when the athletes did, they had more problems. Compared to neurotics with a non-athletic background, neurotic athletes had fewer neurotic markers in their life history, reported more (73% versus 11%) threats to their physical well being as precipitants to their problems, and had a poorer prognosis than the non-athletes. The author did not partial out the physical threat, which may be more real to the athletes. These studies confirm that studies of different populations are just that - studies of different populations, and inferences from correlations are particularly speculative when comparing athletes with non-athletes.

Duration of exercise

There are a few studies where physical activity is experimentally manipulated. Some of these are concerned with physical fitness, where fitness is a stable physiological change as a result of a period of repeated physical activity, usually in increasing levels of intensity or duration. Consequently, research on fitness should be differentiated from that on less sustained exercise or on physical activity. The most consistent findings on the effects of fitness on behaviour (excellently reviewed in Folkins and Sime, 1981) have shown that in all populations studied, physical fitness experience leads to improved mood, improved self-concept, and “better” behaviour at work. There is only equivocal evidence that cognitive function is improved by fitness or exercise, except in
geriatric mental patients where the evidence is more consistent that it is improved (also Powell, 1975).

From the review (Folkins and Sime, 1981) of the effects of fitness on (a) cognition and perception, (b) affect, (c) personality and self-concept, and (d) clinical syndromes, it should be noted that in none of the 39 studies reviewed was there any deterioration in any measure resulting from physical fitness training and some improvement was reported in 72% of the studies. Just looking at the 17 experimental studies, the improvement percentage is increased to a value of 82%, certainly a provocative finding. If fitness is influenced by the amount of physical effort involved, then this variable should influence behaviour.

Morgan and Roberts (1970) varied the intensity of physical exercise using normal subjects, but reported no effect of intensity on self ratings of anxiety or depression. In a well-controlled study, three groups of university students were given either 0, 2 or 4 days/week of physical exercise and self-esteem estimated on a Guttman scale pre and post-test. Results suggested that the frequency of exercise is an important variable (Hellion, 1970; Pauley et al., 1982). Gettman et al (1976) replicated this study using prisoners jogging 0, 1, 3 or 5 days/week, 30 minutes/day for 20 weeks. They found no changes in blood pressure, body weight, or serum lipids in response to an exercise test. They did find that both motivational problems and other improvements in fitness (heart rate and oxygen measures) increased in direct proportion to the frequency of exercise. If not for intensity, then at least there is some evidence that the duration of exercise is an important variable (Gettman et al., 1976; Ismail and Trachtman, 1973).

Self-concept

In the literature on the self and its evaluation, it is usual to distinguish between body image, self-image, body satisfaction, self-satisfaction, ideal self, and self-concept, but research on the effects of exercise is not so specific. Research has pointed to the validity of the following generalisations: (1) that there is a positive relationship between body concept and self-concept as well as between body satisfaction and self-satisfaction; (2) mental health and social adjustment are associated with positive self concept. The bulk of the studies reporting improved mood with exercise suggest that beneficial effects are most apparent for individuals who are either very unfit or very anxious; when beginning, young and fit, psychological gains are not detected (Collingwood and Willett, 1971; Folkins, 1976; Layman, 1974; Poppel, 1980).

Two studies using a within-subjects design (cited in Morgan, 1974b) compared the behaviour of athletes out of season and so presumably less active with their behaviour during the athletic season. Surprisingly, athletes were less anxious out of season than in season, and, as is commonly found, were less anxious both in and out of season in comparison with non-athletes. Four studies administered inventories to individuals who chose not to engage in sport but were later forced to do so (eg at West Point Military Academy). All
four studies reported athlete/non-athlete differences and an "improvement" in the scores of non-athletes after sports experience (Lukehardt and Morgan, 1969; Naughton et al, 1968; Morgan et al, 1969; Schendel, 1965 - all cited in Morgan, 1974b).

Mastery

Because many of the signs of physical arousal seen during physical exercise are also associated with anxiety, therapists have posited that this association provides the opportunity for the patient to acquire a sense of mastery or predictability over them. Mastery of these sensations during periods of exercise would then generalize to similar sensations during periods of anxiety (Cox, 1978; Orwin, 1981); and exercise has thus been used in the treatment of anxiety states. While reliable estimates of its effectiveness are difficult to find, testimonials are not (Antonelli, 1982; Carruthers, 1978; Fentem, 1976; Kostrubla, 1976; Macdonald, 1976, p 255; Morgan, 1974b; Ryan, 1974b; Solomon and Bumpus, 1978; Syer and Connolly, 1984); but for a humorous rebuttal see Epstein (1981, p 181), who cautions that "the reasonable man ... does not confuse sweat with salvation".

Skills

Mastery over sensations is not the only possibility resulting from exercise. Much of the fitness experience also involves the learning of skills. Layman (1974) reported two studies showing that learning swimming techniques results in an improved self concept. Another possible interpretation is that of an assortative effect; it may be that individuals feel better when associating with others who have the same interests and skills (Schellenberger, 1981).

Some support for this notion comes from the handicap literature. In summarizing the effects of different types of education, the authors conclude that segregated education, when compared with integrated programmes, seems to lead to better scores on measures of self-concept in mentally retarded individuals, ie subjects perceived themselves as and were accepted by peers (Haywood et al, 1982). There is the work of Schachter (eg 1964) on the choice of peers during stress which can be summarized as "misery not only loves company but prefers miserable company". The animal work also shows numerous specific assortative preferences for mating (Wilson, 1971), for proximity (Chamove, 1979), and for play (Chamove and Harlow, 1975).

RESTRICTION OF PHYSICAL ACTIVITY

Restriction of exercise is another method whereby one can investigate the relationship of activity to behaviour and to physiology. Fortunately the results of these studies mirror those of studies on moderate levels of exercise.

Physiological changes

Summaries of studies on the effects of immobilisation of parts or all of the body have consistently shown decreases in muscle mass, muscle strength,
heart volume, heart diameter, heart output, and oxygen intake. There are increases in heart rate (e.g., 130 to 155 beats/minute) and in the excretion of nitrogen, calcium, potassium, sodium, and phosphate in the urine and/or faeces (Astrand and Rodahl, 1970; Smolak, 1974). Imposing 20 days of bed-rest on normally sedentary individuals led to measurable changes after only 10 days, but took 35 days in normally active subjects (also Fenton, 1976). A subsequent 50 days of exercise resulted in only a 4% increase in fitness measures in the active subjects when compared to pre-bed-rest measures. In the sedentary group there was an improvement of 35% from pre-bed-rest measures and 100% from post-bed-rest measures (Astrand and Rodahl, 1970). They also controlled for position during rest and concluded that the effects of restriction were not due to the horizontal position, but "may be attributed to the effect of absence of gravitational stresses" (p. 419) during inactivity.

**Sleep**

Sleep is one area believed to be affected by exercise. For example, exercising prisoners reported "better" sleep (Morgan, 1976). Baekeland (1970) followed up a study of his own which had shown that exercising subjects had more deep (delta) sleep on days during which they exercised than on non-exercise days, especially after the second day of exercise. When deprived of regular exercise for four days, normal college students reported increased wakefulness, changes in REM-sleep patterns, increased tension, and an increased need to be with others (also Solomon and Bumpus, 1978). The converse is also the case: sleep deprivation leads to physical fatigue, reports of emotional stress, cognitive disturbances (e.g., reaction-time changes), and physical changes (e.g., in blood oxygen, sugar and catecholamines), effects which are more evident in individuals scoring high on anxiety, neurotic, and extraverted traits (Shephard, 1984) and characteristic of individuals who choose to engage in sport.

When individuals are under stress they show an increase in activity (Drabek et al., 1975) and also report an increased need for sleep (Fenton, 1975). Oswald (1982) concludes that exercise makes sleep come on earlier, deeper, and last longer. Of course improved sleep could produce part of the sense of well-being reported after exercise. Cureton's (1963 also 1967) study of 2,500 normal adults suggests that inactivity led to increasing tension or at least difficulty in reducing tension, although he did not report using any control group.

**Lower levels of stimulation**

Reduction of sensory stimulation is believed to be an indirect cause of reductions in activity. In adult animals there is evidence that this is the case (Anderson and Chamove, 1980, 1981; Hediger, 1968), but in young animals there is no evidence that this is the case (e.g., Kerr, Chamove and Harlow, 1969). For example, the activity levels of young monkeys when alone in a bare cage for a week is the same as that when with the stimulus of either one or five peers; the monkeys play vigorously with themselves when alone and with
companions when these are available (Chamove, 1973). In humans there is evidence that the situation does influence activity levels, at least when the stimulus level is present for a considerable length of time.

Long-term (70% of their lives) hospitalization of non-ill children has been shown to reduce activity to about 40% of the level in normal children (Kielhofner et al, 1983). One of the effects of institutionalization is reported to be lack of initiative (Lipman and Slater, 1979).

There is tentative evidence that adults suffer from inactivity. There is almost a two-fold rise in the probability of death for psychiatric (excluding organic states) in-patients over controls and almost as great a rise for out-patients (Sims, 1978), which may reflect the lower activity levels characteristic of these groups. There is a suggestion that certain types of hospitalized patients may be more influenced by the lack of stimulation found in hospitals and respond by reduced activity levels. For example, schizophrenic patients are less active and less fit than other psychiatric patients (see below). If so, then a breakdown of activity levels by sex and psychiatric group and a breakdown of mortality by psychiatric group would be helpful. This increase in mortality is greater in males than females, but may just reflect the greater sensitivity of males to more adverse conditions (eg Sackett, 1984). Much of the increase is associated with suicide risk, but the effect is still present when excluding suicide.

The probability of death from automobile accidents is 30 times greater in psychiatric populations; is this a form of suicide or deficits in concentration or something else? And finally, several psychiatric disorders have been shown to be correlated with certain diseases such as cancer where no relationship with activity has been reported. The relationship of activity with increased mortality in hospitalized patients is not clear, but is in the expected direction - less activity being related to increased mortality. The studies reported use the most crude statistics and do not partial out confounding variables which would help to apportion causation.

Mental handicap

Some evaluation of the effects of exercise specifically on behaviour has been done using other handicapped groups where prior lack of stimulation and lack of exercise may have been prominent. Nunley (1965) studied 11 mentally handicapped juveniles giving them simple physical exercises. He reported a subjective impression of "astounding changes" (p 949) within one month, specifically more conformity to staff requests, awareness of others, confidence, and enthusiasm. All subjects showed overall improvement on a 13-item test of motor ability, and 62% of the cells of the item-by-subject matrix showed improvement; only 3% showed deterioration, most concentrated in a single individual. Oliver (1971) too found an increase in confidence after strenuous physical exercise, likely a skills effect.

Brown (1977) gave 40 trainable mental retardates a programme of exercise. While controls did not show change, the handicapped individuals showed
improvements in strength and social skills (Vineland Social Maturity Scale). Unfortunately the author did not specify which items or categories of items within the Vineland reflected the changes. Collingwood (1972) compared four weeks of vigorous physical exercise with standard "rehab" controls and found more improvement in physical, intellectual, self-attitude, and inter-personal measures with the exercise group. With only these few studies available, we can conclude that mentally handicapped individuals appear to benefit from physical exercise programmes.

Geriatrics

Clark et al (1975) randomly assigned geriatric mental patients to an exercise group, a control group, or an attentional control group of social activity, and measured fitness, co-ordination, and activity level which was estimated as caloric cost from staff ratings. Total daily activity increased during the exercise period and four weeks after the exercise in the experimental but not the control groups. It is of interest that daily activity correlated with measures of physical co-ordination, suggesting that co-ordination might limit activity in geriatrics, and that improving co-ordination might be one channel by which exercise might affect behaviour in this population.

Obesity

Obesity is another area of study where low activity levels may be implicated. Research on the role of exercise in obesity ties together two benefits of exercise: (1) exercise reduces obesity, and (2) both activity and a reduction of obesity lead to improved self-image. The findings reported in the obesity literature suggest that the major pathway by which exercise reduces body weight is through enhancement of "diet-induced thermogenesis", that is, the increased ability to dissipate energy when an excess of food is eaten (Black, 1983). But (a) this is true only when the body is in some moderate degree of energy imbalance, and (b) this is less pronounced the greater the degree of imbalance. "Much of the evidence on the role of low activity levels in the development and maintenance of obesity is anecdotal" (Black, 1983, p 37), but there is evidence that sedentary workers eat more than those who indulge in moderate activity (Stock and Rothwell, 1982).

Studies on physical activity in fat and lean individuals give little evidence that inactivity is a characteristic of obese adults, although it may be of male children (Thompson et al, 1982). Exercise does lead to some positive benefits concerning caloric intake, metabolic rate, body composition, and lean body mass, all of which in turn affect energy output.

If we look briefly at hereditary predispositions, children of obese parents eat about 20% less and are about 20% less active than children of parents of normal weight (Black, 1983). Furthermore there are large differences in the energy expenditure between individuals of similar body weight doing the same activity (Durnin and Passmore, 1967). Persons of the same age, sex, and weight may differ in basal metabolic rate by as much as 30% (Dishman, 1980). Above a certain level of activity, food intake increases in line with work
load but results in no increase in body weight. At very low and very high activity levels, both body weight and food intake actually increase (Stock and Blackwell, 1982). The animal literature supports this trend for low levels of activity (Katch et al, 1979).

The animal literature also suggests a connection between the body weight research and anxiety level. Rat strains bred for high levels of emotional reactivity (Broadhurst, 1975; Imada, 1972) or strains that differed in emotionality levels (Chamove and Sanders, 1980) were shown to have higher body weights and to be less active than calmer rats. There has been no attempt to disentangle these correlations (Archer, 1975).

THE PSYCHOTIC PATIENT

It has long been known that schizophrenic patients score well below normals and below other psychotic patients on several measures related to physical activity and physical fitness (Gordon et al, 1966; Harrington and Cross, 1962; Hodgdon and Reimer, 1960; Lindquist, 1981; Linton et al, 1934; Morgan, 1968, 1974; Rosenberg and Rice, 1964). Schizophrenics are lower on cardiovascular fitness, muscular strength, and most measures of endurance (Morgan, 1974b). Fitness was estimated to be about 30% below normal standards with regard to muscle strength and endurance (Hodgdon and Reimer, 1960); all but 7% of the 42 hospitalized male schizophrenics were below two standard errors of the mean of normal unhospitalized controls. When comparing recently hospitalized schizophrenics with those hospitalized for prolonged periods, those recently hospitalized were not below normals on the above measures (Morgan, 1974b), suggesting that some changes are a function of inactivity, resident schizophrenics being found to be about half as active as non-schizophrenic psychotic patients (Lindquist, 1981). Not surprisingly, long-term patients were below recent admissions too (Rice et al, 1961).

Active Leisure

Participation in active forms of leisure pursuits seems to be the factor that differentiates schizophrenics from other populations (Harrington and Cross, 1962) and not in inactive leisure pursuits (Campbell and McCready, 1983; Denney and Myersohn, 1957; Hare, 1967; Robertson, 1957). Reed (1926, cited in Linton et al, 1934) sub-divided 275 schizophrenics into thirds and found the "indolent" sub-group were below the "active" sub-group in fitness, but there was considerable overlap in estimates. An older study compared recently hospitalized (< 4 days) schizophrenics with those in hospital for longer (1-8 years). The long-term patients were about 10% below the recent admissions on fitness, a non-significant difference using only the simplest of analyses (Rice et al, 1961). Other studies show 55% of schizophrenics falling below and outside the activity range of normals (Linton et al, 1934). This was true even in recently discharged schizophrenics (Gordon et al, 1966) who were reported to spend the majority of their time watching television; no controls were used. But a comparison with normal individuals shows that they
too spend considerable time watching television, and do not differ from schizophrenic individuals (Denney and Meyersohn, 1957; NRA, 1934).

In fact it is the relative lack of schizophrenic participation in active leisure pursuits that differentiates them from non psychiatric patients (Harrington and Cross, 1962). Less than 2% of discharged schizophrenics reported participation in active sports (< 1% in Robertson’s in-patients), although 5% watched sports; whereas 55% of normal individuals reported regular sports participation. There was no association of participation in sports, social gatherings, or hobbies with mental status nine months after discharge, but there was a positive correlation with both an increased number of activities (not found in Robertson, 1957) and with greater participation in activities, and both mental status and working in the community. Predictors at discharge of individuals who were subsequently found to be in employment were "an optimum amount of energy displayed in ... gait and posture, ... and a reported preference for outdoor sports” (Gordon et al, 1966 p 457).

**Sex differences**

There are sex differences in these patterns too. In a retrospective study of psychiatric patients, women reported that before their illness they spent more time in bed and more time with friends and family than did men. Men spent more time in clubs, in sports, in hobbies, and gambling than females and were more active in their activities than females, who were more passive and creative. Over 37% reported changing their pattern of activity with the onset of illness; previously active users of leisure time became more passive and less social (also Robertson, 1957). Schizophrenics show several physiological abnormalities which could be related to activity. Blood pressure reactivity when changing from reclining to standing in 99 unmedicated schizophrenic patients was considerably less than in normal staff controls (Campbell and McCreadie, 1983).

Other abnormalities in schizophrenics which one might expect to be attributable to inactivity, are in fact characteristics of the schizophrenic condition. There is evidence that fitness is influenced by both. Poor performance scores on vestibular measures were not exacerbated with increasing hospitalization in schizophrenics and were not evident in inactive spinal-pain control patients (Lindquist, 1981). It may be that reducing the level of physical activity can induce altered perception in adults.

Piaget (1963) has argued, citing little evidence, that the sensory motor period of development is essential for the later development of the ability to interpret and think. There is now some evidence that for certain activities there is at least a positive relationship between practice in a specific activity and some aspects of perception in that activity. For example, athletic activities lead to improved perception in the visual modality but not in auditory perception (Layman, 1974).

There are suggestions that hallucinations may be influenced by exercise. Along that line, West (1962) speculated that hallucinations resulted from a
disequilibrium of external sensory input under conditions of high autonomic arousal; and Fisher has modified this idea, speculating that hallucinations result from a relative lack of motor "verification" of sensory experience under conditions of over or under-arousal (1975).

**Coping strategies**

It may be that schizophrenics, like depressives, recognize a link between exercise and some of their abnormal behaviours. When schizophrenic subjects were asked to describe the strategies they used for coping with auditory hallucinations, subjects reported using (a) changes in activity (including postural changes), (b) changes in inter-personal interaction (especially increases), (c) changes in physiological arousal, and (d) changes in attention (Falloon and Talbot, 1981; also Paul, 1977). To alter arousal, 78% of informants reported that they increased arousal by exercising, which was most successful when hallucinations were occurring during hypo-arousal. Those strategies which were used relatively more by subjects judged as "coping better" were: reduced attention to hallucinations, relaxation, and increased leisure activities; whereas increased inter-personal contact was the strategy of first choice by "poorly coping" schizophrenics.

Two studies testing the effects of hydrogymnastic* activity on behaviour are of particular interest because in one study, specific activity was assigned randomly and the results on behaviour measured soon after, and in the other, a within-subjects design was employed. 27 psychotic patients were observed for instances of aggressive and restless behaviour, and also blindly rated on several behavioural factors. Half were given two weeks of hydrogymnastic competitive games (eg water polo). Although there were no changes on the ratings of abnormal excitement or activity levels, melancholy agitation was reduced by the therapy, and there were anecdotal reports of improvements in relaxation immediately following swimming. Also the sum of the six rated factors, called morbidity, was reduced by the hydrogymnastic therapy. During the swim phase there were no effects on the observed behaviours (Kramer and Bauer, 1955). Timmerman (1954) took advantage of a five-month period of repairs to a swimming pool to compare the amounts of treatment given to 25 male psychotic patients. When hydrogymnastics were no longer available, other treatments (ie seclusion, chemical sedation, hydrotherapeutic sedation) increased by 60%.

From the above, it seems reasonable that an attempt should be made to assess the effects of activity and exercise on chronic psychiatric patients, including chronic schizophrenics. "Although there is so far little solid evidence to support it, recreational exercise appears to be therapeutic for institutionalized psychotic patients" (Ryan, 1974b, p 420; also Morgan,

*Hydrogymnastics* - therapeutic swimming including games performed in water, usually at a temperature of 90°F.

*Hydrotherapy* - application of neutral wet-sheet pacts or use of flow tubs for sedative purposes (Timmerman, 1954, p 193).
1974b). If nothing else, exercise is within the normalisation idiom. Layman (1971) reviewed four studies on hospitalized psychiatric patients and found that three of these studies showed beneficial effects of physical exercise on adjustment. One similar study reported that individual isometrics did lead to strength gains but not to any other behavioural changes in 20 schizophrenic patients as compared with control schizophrenics. The lack of any other effects on behaviour were attributed, say the authors, to compliance problems with the schizophrenics (Smith and Figetakis, 1970). At least some of the data presented cast doubt on the compliance interpretation (eg p 102, figures 1 and 2). It is not possible to assess the statistics used in the behavioural comparisons, but a comparison of the group-means presented suggest to this author that behavioural effects were indeed present. Another study using 18 mixed psychiatric patients found that self-reports in response to various questionnaires showed a decrease in hostility but an increase in manifest anxiety in response to light exercise (defined as no increase in pulse rate). Greater exercise (jogging) led to reduced body tension and anxiety and greater alertness (Dodson and Mullens, 1968). The statistics of this study are questionable; the authors used 45 t-tests for the behavioural results alone, and the conclusions would be unlikely to be the same using multivariate techniques which would avoid the multiple-t error.

**Excitement**

There are caveats when involving schizophrenics. Stimulating environments in the workplace, treatment setting, or especially the home have been shown to be associated with higher rates of relapse (Linn et al, 1980). This stimulation is usually described as conflict, expressed emotion, criticism, and face-to-face contact. One may think of exercise as stimulating although it does not fall within these categories. Also exercise does not lead to increases in blood pressure as one would expect if it were a stressor (Dworkin and Miller, 1977). In addition exercise may function to focus attention, a problem in schizophrenia (see Attkisson and Anker, 1970). Competitive sport may be face-to-face and is arousing (Gelfand and Hartman, 1976) and may need to be more closely monitored in schizophrenics. Furthermore, exercise, if involving "repetitive movements reasonably constant both in amplitude and frequency", and if the frequency was about 1/second would fall within the definition of a stereotype (Berkson, 1983, p 241) and may be calming in effect. Stereotypic behaviour was an important part of the original description of schizophrenics, and it may be especially attractive to the schizophrenic individual (Frith and Done, 1983).

**Reward**

A final caution concerns the response of other individuals to the subject's behaviour. A series of studies have shown that response-contingent censure is more effective in motivating schizophrenics than response-contingent praise (Attkisson and Anker, 1970). The provocative and rarely cited work of Warkentin (1956) may be relevant here. More recently interest in this area has been revived and termed the "over-justification effect". It suggests that rewarding a behaviour may cause a reduction in the intrinsic motivation to
engage in that behaviour (Ogilvie and Prior, 1982). Rewards convey at least two messages: either competence and self-determination, or external locus of control (Lepper and Greene, 1975). A similar phenomenon has been reported in monkeys where it was shown that monkeys would disassemble complex mechanical puzzles even when no conventional reinforcers were provided for the correct solution. In fact when food was given at the end of the puzzle series, fewer puzzles were attempted and solved (Harlow et al, 1950).

**Competence**

Ismail and Young (1973) have presented a general psychological theory which suggests that psychological and physiological changes occur when an individual confronts a challenge (eg an exercise programme) and masters it. The suggestion of this theory of competence is that challenge leads to self-control and the two become associated through pairing. Support for the importance of controllability has been found (eg Canter and Canter, 1979; Rodin et al, 1980).

The above review would support a competence interpretation for the beneficial effects of exercise in that the maximal effects of exercise were found in the unfit, the anxious, the hospitalized, and the overweight. Of course it has been known for some time that success experiences in themselves lead to reduced anxiety levels and that failure experiences lead to increased anxiety (Gaudry, 1977). One might further expect success experience to be even more important in mentally handicapped populations (Chamove, 1984; Riese and Lobb, 1967).

**Summary**

It appears that there is consistent evidence that exercise has both immediate and long-term effects on behaviour. The reliable effects from experimental studies or from repeated quasi-experimental studies can be summarized as follows: moderate exercise has short term effects on aggression (animals), self-injurious behaviour, subjective reports of feeling better, anxiety, fatigue, and (muscle)tension; it has long-term effects in the reduction of anxiety, muscle tension, response to stress, and self-concept (physical, social, and personal). These effects are much less marked when the subject is young and fit.

In studies involving exercise, there are a number of factors which often confound results. They need to be controlled - either experimentally or statistically - as most have been shown either to influence or to bias results. These factors include the socio economic status of participants, the weight and dietary changes which accompany changes in exercise, and the learning of skills and development of competence which often accompany exercise. The different levels of attention, change/distraction from everyday behaviours or worries, fatigue effects, plus the fact that exercise takes up time, also influence results, as do different baselines and the finding that increasing fitness with exercise alters subjective judgement of levels of exercise, effort, and physiological changes. Differential drop-out rate, expectations of change,
and the fact that controls often choose not to exercise also complicate interpretation.

In the analysis of mechanisms by which exercise alters behaviour, it may be important to separate mental activity from physical activity and control the contribution of each. The repetitive nature of some exercises like aerobics might have unusual effects. Team versus individual exercise and competitive versus non competitive exercise might be expected to have different effects too. The degree of effort involved has been shown to be important.

When measuring the effects of exercise on behaviour, the literature suggests that it is important to measure a number of behaviours to assess the specificity of the activity effects; to bear in mind that exercise may have differential latencies in its effects; that changes may be brief or prolonged; that the frequency and intensity of exercise may affect behaviour; and also that previous activity level and duration of hospitalization may be important. It may be desirable to further sub-divide exercise into those muscle masses which are involved. Most studies looking at the connection between exercise and behaviour have assessed the effects of exercise on a series of global measures of behaviour using one or two populations. For example, these studies are able to say that exercise reduces assessments of anxiety or extraversion in mild depressives. There are almost no reports of statistical controls or statistical discrimination concerning either attributes of the populations or the measures taken. Furthermore, there are almost no reports of direct observations of behaviours. From findings in other areas of psychology it seems likely that exercise will affect certain categories of persons within a population more than others, that direct measurement of behaviour as an inference of more global concepts may be more sensitive to effects of exercise than subjective assessments, and that statistical control will lead to more powerful statistical tests.

Several hypotheses concerning short-term effects of exercise were generated from consistencies in the literature. The few studies on schizophrenics suggested that exercise may lead to (1) reduction in disruptive behaviour and (2) increases in activity. Research on other populations indicates that exercise leads to (3) reduction in depression, improvement (4) in mood (especially anxiety), (5) in sleep, and (6) in movement abnormalities, and (7) no change in extraversion or affiliative behaviour. The animal literature suggests that exercise may lead to less (8) time spent in inactivity and (9) negative behaviour (aggression and abnormal behaviours). With the exception of the sleep variable, the following study will assess whether these categories of behaviour are changed on those days in which schizophrenic patients have previously engaged in some form of exercise.

A STUDY OF ACTIVITY IN SCHIZOPHRENIC PATIENTS

Subjects

The patients tested were 40 patients currently diagnosed as long term schizophrenic by both consultant and senior nursing staff. They came from
three different wards in Roslynlee Hospital, two wards in the Royal Edinburgh Hospital, and the Cambridge Street Day Hostel associated with the latter. The variety of settings was chosen so as to increase the variability in patients, settings, activity opportunities, and any reinforcement contingencies that might be present.

**Equipment**

The Nurses' Observation Scale for In-patient Evaluation (NOSIE) was chosen as the main questionnaire instrument for assessment of behavioural change. This 31-item questionnaire has been extensively utilized, evaluated, and factor analysed (Philip, 1977; Walls et al., 1977). The following seven factors emerge: Social Interest, Social Competence, Personal Neatness, Irritability, Manifest Psychosis, Retardation, and Depression. Personal Neatness was not of interest and therefore not analyzed. Four questions were added to the form used by the nurses reflecting movement disorder, one on initiative, and one on tension (details in Chamove, 1986a). The nurses filled in the full form of the NOSIE and patients filled in an abbreviated form. For the latter, one question was chosen from each factor, that question with the highest factor loading and rephrased (a) as a question to a patient and (b) to reduce any pejorative connotations.

**Procedure**

This study was designed to look at short-term changes in schizophrenics, comparing behaviour after varying amounts and types of activity. Constraints prohibited the imposing of activities so use was made of normal variations in the opportunity for activity and variability in the degree of energy expenditure by the different patient groups. Those activities chosen by patients were influenced by two factors: subject choice and the activities offered by the ward where individuals were resident.

Before the study was begun, all subjects were approached, and an explanation of what was needed was given, although not the purpose of the study. Patients were advised that they might withdraw their consent at any time during the study (Zangwill, 1973). Two subjects took advantage of this and withdrew during the study; none of their data was used in the analysis. The purpose of the study was described to both patients and nurses as one designed to look at the variation in behaviour and mood on different days of the week. Therefore both the patients and the nurses were rating blindly. Anyone with a condition which would disqualify them for sports participation according to the Committee on the Medical Aspects of Sports (in Allman, 1974b p 102) was not included; these were quite serious ones and in fact only one person was so disqualified.

All activity sessions were rated for 2-4 days. All activity sessions were compared with data collected over a period of 2-4 days when the activity did not happen. Consequently behaviour could be compared on days when the exercise did not take place with behaviour in the same subjects on days during which it did take place. We tried to avoid, whenever possible, active
days being weekdays when inactive days were weekends because of other possible differences between activities during these two types of days. The categories of activity were keep fit exercises, occupational therapy, work therapy, gardening, and swimming. For analysis they were divided into a mental exercise component and a physical exercise component.

The ratings were done at least but as close to two hours after the exercise as possible and at least two hours after meals (see Linton et al, 1934). The 36-item nurse questionnaire was filled out first by one nurse, and then the 13-item self-rating of the patients was completed. The latter was presented to the subject by a different nurse, preferably and usually on a different day. These raters were consistent throughout testing so as to reduce within-subject variance on repeated measures as much as possible, and nurse and patient scores were rated separately so that nurse questionnaire ratings were not influenced by the subject's self reports.

**Covariates**

As the length of hospitalization has been shown to affect both behaviour and response to exercise (Folkins, 1976; Kielhofner et al, 1983), this variable was recorded as duration of the present hospitalization (mean = 14, range =1-15 years). Also recorded as the subject's age ((M = 50, R = 20-77 years) (Folkins, 1976), height, weight, level of medication, an estimate of degree of pathology (Collingwood and Willett, 1971), and an estimate of the amount of physical exercise normally taken by the subject (M = 380, R = 0-1720 calories). The last was made by nurses and converted into calorie expenditure estimates from standard tables (Tarnower, 1978). This was done to estimate level of initial fitness, which also has been shown to be important in response to exercise (Folkins and Sime, 1981). The estimate of severity/pathology was made by the consultant on a 0-7 scale. Both estimates were made just before the data recording was begun. The level of psychotropic medication was converted to equivalent potency units of chlorpromazine for statistical purposes. This was done by estimating their effectiveness as dopamine receptor blocking agents (Kendell and Zealley, 1983; Seeman, 1981). The weight and height information was converted to 'percentage overweight'. (M = B, R =11+40%) (Black et al, 1983; Stock and Rochwell, 1982) using standard tables (Metropolitan Life Insurance Co, 1972).

**Analyses**

The first stage of analysis involved two large analyses of covariance (ANCOVA) to answer the questions:

Were there overall effects of activity on the nurse or self-rating scales of the NOSIE?

The first analysis was a Groups Physical (2) X Groups Mental (2) X Activity (2) X Rater (2) X Measures (6) with 6 covariates where the last 3 factors were repeated measures. Covariates for these analyses were sex, severity, weight, medication, normal exercise, and additional exercise.
The second step involved a more detailed analysis after a significant effect in the overall ANCOVA or where a priori comparisons were indicated (Brown and Tinsley, 1983). These were Disruption, Depression, Activity, Psychosis, Affiliation, Tension, and Movement Disorder.

Then a Pearson Product Moment Correlation Co-efficient was computed between these difference scores and all of the covariates. Three new variables were also formed combining all NOSIE scores, all NOSIE nurse scores, and all NOSIE self-rated scores.

Results

The results indicated that all the patients were rated better on all of the NOSIE measures on activity days in comparison with less active days. The overall analysis of covariance on all NOSIE scores taken over two raters and over the two activity conditions showed one significant result related to activity, the overall activity effect, \( F(1, 30) = 10.31, P = 0.003 \). This result was taken as justification for looking at the data in more detail. Overall activity effects were found upon subsequent analysis of five of the eight categories concerned with the hypotheses. Significant improvements resulted from ratings of disruption (\( F = 9.29, P = 0.004 \)), movement disorder (\( F = 4.65, P = 0.038 \)), depression (\( F = 7.99, P = 0.030 \)), retardation (\( F = 4.38, P = 0.04 \)), and tension (\( F = 15.71, P = 0.0004 \)). Figure 1 (on the following page) illustrates the results.

A Pearson correlation co-efficient was computed between all covariates and the NOSIE scores, using 'change from no-activity to activity' scores. When looking at the aggregates of scores, there are more improvement in NOSIE nurse ratings in those who were more overweight (\( r = +0.35, P = 0.04 \)). Greater improvement in NOSIE self-ratings were found in females (\( r = +0.42, P = 0.01 \)) and in less severely rated patients (\( r = -0.34, P = 0.03 \)). Similar results were found when using the combined NOSIE ratings, more improvement in females (\( r = +0.44, P = 0.005 \)) and in less severe patients(\( r = -0.36, P = 0.03 \)). In addition, improvement in this score was associated with being more overweight (\( r = +0.40, P = 0.01 \)). Groups with lower levels of physical activity improved more than those with higher levels on their active days; those with higher levels of mental activity tended to show greater improvement that those with lower mental levels on the active days. More detailed description of results can be found in Chamove (1986b).

Discussion

Results have shown that when long-term schizophrenic patients were rated on days in which they were relatively more active and compared with ratings on days on which they were less active, both by nurses or by themselves using the NOSIE rating scale, almost all categories showed some improvement on more active days. Patients showed significantly less psychotic features, less
Figure 1

Changes between no-exercise and exercise days for 8 behavioural measures, showing both nurse ratings of schizophrenic patients and the patients' self-ratings.
movement disorder, were less irritable, less depressed, less retarded, less tense, and showed more social interest and more social competence. Correlations indicated that the greatest improvement was found in less severely disturbed patients, in more overweight individuals, in females, and in more sedentary patients, and perhaps in those with only moderate increases in exercise. All of these correlations were supported by the literature using other populations except for the greater sensitivity of females to the beneficial effects of activity.

The predictions from the long-term effects of activity on behaviour were largely supported by the short-term effects found here. Although small, the consistently beneficial effects of activity in a population where behavioural treatment has not been promising, suggest a direction for interventions in this difficult group. This is not to suggest that inactivity is the cause of their illness, simply that altering their behaviour towards more activity improves it. There is the suggestion that occupational therapy and work therapy have benefits not recognized before.

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EXERCISE EFFECTS IN ANIMALS: A THEORETICAL EXPLANATION FOR HUMAN EXERCISE

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Introduction

Why do individuals choose to exercise and why does activity produce its beneficial effects? There is at present no satisfactory theoretical explanation.

Psychologists have put forward a model to explain how exercise techniques reduce abnormal behaviour patterns. Many of the techniques they use involve breaking into and often altering the information involved in a feedback loop (eg Cox, 1978; Lazarus, 1966). For example, both activity and inactivity lead to changes in the rate of heart beat; heart rate may be noticed and is often interpreted as abnormal by the individual; and that interpretation may further alter heart rate by increasing anxiety (Fowles, 1982). Changing heart rate by changing behaviour, breaks into or alters the information in the above feedback loop. Let us refer to this as the behavioural model. This idea has been elaborated in a more general cognitive model of adaptation and emotion (Heaps, 1978; Lazarus, 1974, 1975) which includes coping strategies and the concept of competence (to be discussed below). If the above model is an accurate and important description, then it describes one mechanism by which activity might lead to changes in behaviour.

A second way of theoretically explaining a connection between activity and behaviour change is what I term an evolutionary or a sociobiological model. This explanatory position would suggest that individuals have evolved in such a way that certain behaviours are prevented by external circumstances (and perhaps even by the individual itself), behaviours that are by definition "abnormal" must take their place. As an example, given that individuals are biologically programmed to spend a large proportion of the day working in search of food, if this activity is prevented, a large proportion of the day will now be occupied with behaviours which normally occur less frequently. This time period may be filled by sleep, by stereotyped behaviours, or by "creative" behaviours. This suggestion has not been postulated before in the literature concerning exercise and behaviour with respect to humans (eg Kincey, 1981) and will be expanded below. It would be compatible with a clinical ecological interpretation of environmental causes of illness (Rippere and Adams, 1982; also Studer, 1969).

Other theories (eg Somatopsychic model: Harris, 1973) seem merely to state that physical activity is good because it leads to positive psychological responses and positive behaviour. There is no suggestion of a mechanism of influence. Finally the psychoanalytic literature speculates about other benefits from exercise in psychiatric treatment (eg Davis, 1948, esp pp 346-7).
It is curious that the occupational therapy literature does not contain references to any of these arguments for the use of exercise in the treatment of patients (e.g., Macdonald, 1976; Mosey, 1980). In this literature, the rationale for the use of exercise is in the development or redevelopment of function or skills, such as in handicap, in stroke victims, or in long-term hospitalized patients (e.g., Campbell and McCredie, 1983). A search of the occupational therapy literature was unsuccessful in unearthing evaluative studies of the effects of exercise on behaviour, other than practice effects.

The Sociobiological Model

Now to expand on this idea of a link between normal activity and the beneficial effects of exercise. Looking from a sociobiological perspective, one would posit that inactivity is unnatural (Price, 1984) and therefore would lead to an increase in behaviours which would be by definition abnormal in their frequency of occurrence, to fill gaps which would normally be filled with activity. More specifically the reduction in any relatively frequent time-consuming or energy-consuming behaviour would lead to an abnormal patterning of behaviours, the degree of abnormality being affected by the importance of the behaviour being reduced. It is difficult to assess the importance of physical activity from the literature, but Malinowski (1944) lists movement as one of the seven basic needs of man.

To determine what is natural, sociobiologists would collect data from those groups of people which were most closely matched in their patterns of behaviour with those of mankind during most of its evolutionary history, that is, the hunter-gatherers. The most detailed study in this area is that on the Ikung Bushman (Blurton-Jones and Sibly, 1978). In a detailed analysis of energy expenditure in Ikung females, they report the following: that women are usually either pregnant or with a child under six years of age; the females always carry the youngest child when it is under two years old and frequently carry children under the age of four; the women carry food (average weight = 9 kg) for half their foraging distance; they collect food travelling an average of six miles from their village and collect water on average one mile from their village, walking at an average rate of three miles per hour; and they forage like this on an average of once every two days. By my calculations, on average these women are carrying the equivalent of 25 kg over a minimum of seven miles for a minimum of three hours every day, an energy expenditure of an estimated 900 calories. This estimate of physical work activity is only for foraging for food and collecting water, and it does not include other forms of physical activity which were not reported. Male activity also was not reported, but is likely to be lower or more sporadic; this difference would lead to predictions of sex differences in exercise effects on behaviour, exercise being more important for females.

More detailed work has been done on foraging and physical activity in non human primates. Aboreal howler monkeys spend over 10% of their day-time hours travelling (1.5 hours per day), over 16% of the day foraging for food, and 65% resting (Milton, 1980). In more impoverished habitats, this 26% activity is increased so that up to 70% of the day-time is spent in foraging-related
activities (Clutton-Brock, 1977). A review of seven different studies of time budgets of aboreal leaf-eating monkeys showed an average of 8% of the day spent moving, 33% spent feeding, 10% in social interaction, and 45% inactive. In these studies about 10% of the individuals were juveniles and another 10% infants, both of which were more active than adults. Inactivity levels of just adults were slightly higher than the mean, about 55% of the day-time (Marsh, 1981). Feeding-related activity in the terrestrial green monkey and gelada baboon, inhabitants of the hot, dry, and open savanna and mountains, occupies almost 50% of the day (Harrison, 1983; Dunbar and Dunbar, 1988). Terrestrial chimpanzees conform to the high monkey commitment to physical activity. These apes spend between 50% and 70% of the day feeding plus a further 14% travelling, and only spend 10%-25% in inactivity (Riss and Busse, 1977). This last comparison of chimpanzees with man is more informative as their diet and physiology is closer to that of man than leaf-eating monkeys which eat large quantities of food with low nutritional value.

When these feeding-related behaviours are artificially curtailed, for example in zoos, by not giving animals the opportunity to travel and to forage and by feeding an animal all of its food at once and without any work being needed, abnormal behaviours result (Hediger, 1968; Meyer Holzapfel, 1968). In caged animals several studies have been done to partially replace this 25% to 70% gap in the day with some physical activity.

Manipulanda have been provided which reward hunting or other vigorous activity with food (Freedman, Gemlo and Pawley, 1983; Markowitz, 1982; Murphy, 1976; Schmidt and Markowitz, 1977). When this has been done, there has been a rapid reduction of abnormal behaviours, such as aggression and stereotypy, even when these behaviours have been developed over and maintained for long periods of time (and see Bielitzki, 1979).

Other researchers have just provided foraging opportunities or made food more difficult to find or to eat (Chamove and Anderson, 1979; Chamove et al, 1982; Chamove, in press). Under these conditions the animals spent over 30% of the day foraging (see Figure 2). These simple manipulations led to a decrease of aggressive behaviour in aggressive macaques to between one third in adults (also Stolba, 1981 studying pigs) and one tenth in juveniles (see Figure 1), and a decrease of other "undesirable" behaviours to about one-fifth of previous levels; affiliative behaviours were slightly but consistently lowered (also Stolba, 1981). Different monkey species showed different magnitudes of the effects, but all primate species tested showed similar trends. The importance of energy expenditure in the efficacy of these activities and the degree to which these replacement activities have to be "natural" behaviours is not known.

The amount of aggression decreases directly as the amount of foraging activity increases. We looked at these two behaviour patterns under four conditions: (1) when the floor was bare and the monkeys had little to do, (2) when the floor was covered with clean woodchips with no food mixed into it, (3) when the woodchip litter had grain mixed throughout, and (4) with the grain-litter mix available but also when monkeys were offered free grain in hoppers.
Levels of aggressive behaviour in 6 primate species on days in which the floor was bare compared with days when the animals were active foraging in woodchips for grain.

**AGGRESSIVE BEHAVIOUR**

- **Cebus**
- **Vervet**
- **Lemur**
- **Cephus**
- **Squirrel**
- **Stumptail-ad.**
- **Stumptail-juv.**

**PERCENT OF TIME OBSERVED**
Figure 2
Levels of foraging and aggression (multiplied by 10) by stumptailed macaques under 4 different woodchip conditions.
As illustrated in Figure 2, even when also given continuous free access to the same special foods they were searching for, macaque monkeys chose to work by foraging for a considerable portion of the day (Anderson and Chamove, 1984; also Neuringer, 1969), and they also would forage in the clean litter with no extrinsic reward at all.

Another area where this question has been indirectly assessed is in relation to abnormal behaviour, especially self-injurious behaviour (SIB). Although the cause of SIB in children is not known (Cataldo and Harris, 1982; Favell et al., 1982), one strong contender would surely be rearing in an environment with low levels of sensory stimulation, physical, and mental activity (Horner and Barton, 1980; Jones, I, 1982; Ross and McKay, 1979). Once SIB has developed, the rate of its occurrence is probably multi determined. SIB may be an operant for positive reinforcement, but recent work suggests that the opportunity for contact with simple but novel toys will substantially reduce the frequency of SIB (Favell, et al., 1982). In one study changes in the levels of SIB were consistently associated with different stimulus conditions in different subjects. Only the opportunity for play with toys led to reduced SIB in all subjects; whereas social stimulation, intellectual stimulation, or isolation led to variable changes in the different subjects (Iwata et al., 1982). Here again, the return to more "normal" levels of stimulus complexity has led to the reduction of abnormal behaviours. Recently exercise has been shown to reduce the level of "inappropriate" behaviours; the greater the amount of exercise, the greater the reduction in the behaviours (suggesting some fatigue effects), with the greatest effect being soon after the exercise (Bachman and Faqua, 1983).

Another related area is that of stereotyped movement. Here too the presentation of certain stimulating circumstances may lead to a decrease in the duration of stereotyped behaviours (Berkson, 1968; Chamove & Anderson, 1981), although very high, possibly stressful levels of stimulation often exacerbate stereotypy (eg Goodall and Corbett, 1982). One theory to explain the relaxation effect of exercise is relevant here (Schwartz, Davidson and Goleman, 1978). In this theory anxiety (and perhaps other undesirable stimuli) are seen as recycling or reverberating, whereas exercise (or any other activity) competes for the limited channel capacity available for behaviours and for cognitions. This idea is extended by the Lyon-Robbins hypothesis (Robbins, 1982), which suggests that activation leads to competition of behaviour patterns and emission of only short response elements, eventually only motor elements which are fragments of more complicated sequences. It seems that increasing any behaviours which compete for time with stereotyped (or indeed any) behaviours which are prominent in the repertoire of an individual, leads to a reduction in stereotypy (Berkson, 1983). For this reason, any study assessing the effects of competition between behaviours must take into account this competitive effect and not only assess the effect of manipulations on "problem" behaviours. The work of Chamove et al (1982) in trying to reduce SIB in zoo animals is exemplary: When enticing their subjects to forage by using extremely desirable and succulent food items (maggots), not only did the frequency of several undesirable behaviours
decrease but behaviours categorized as positive (eg affiliative behaviours) also were slightly reduced under the extreme condition.

In monkeys the cause and treatment of SIB is clearer than in humans. Deprivation of physical contact with other monkeys in the first few months of life, especially during daylight hours, clearly leads to the development of a permanent tendency towards SIB in species predisposed towards the development of SIBs. Once developed, the frequency of SIB can be temporarily reduced in many different ways; most of these involve increasing sensory stimulation or increasing the possibility/necessity for either physical or mental activity (Anderson and Chamove, 1980, 1985; Chamove, Anderson and Nash, 1984; Clarke, Juno and Maple, 1982; Nash and Chamove, 1981).

Most of the studies exploring the effects of physical activity on behaviour have been concerned with long-term effects, both of repeated exposures to physical activity over more than a few days or usually weeks and also monitoring effects on behaviour which last for a few days beyond the day on which the activity was performed. The exceptions are the studies concentrating on the effects of activity changes on physiological measures and not on behaviour as such. Of course a behavioural model would say that physiological changes are important as they have a powerful influence on behaviour (Candland et al, 1977; Levit, 1971; Schachter, 1964). More direct effects on behaviour have been suggested, for example that rapid changes in blood sugar, especially hypoglycemia, might account for the increasing levels of aggression found in some cultures (Bolton, 1978).

Correlational studies show physiological correlates with physical activity, some of which have been confirmed in animal experiments. Physical exercise leads to reductions in blood lipids, especially cholesterol and triglycerides (Kramsch, cited in Vines, 1984; but see Gettman et al, 1976 when diet is controlled), as well as reductions in thyroid function (Adler et al, 1981). It also leads to more efficient glucose metabolism, and a more rapid destruction of blood clots (Vines, 1984). However most studies do not control either experimentally (exceptions being the twin-studies of Bouchard and Loire, 1984 and Gettman et al, 1976 using prisoners) or statistically for those body weight changes or dietary changes concomitant with the exercise regime (exceptions being Jones, A, 1982 and Horton, 1981). Exercise also leads to decreases in body fat content (Allman, 1974; Jones, 1982) and is followed by increases in several tissue masses, especially muscle, lung, heart, and bone. Exercise leads to heart changes (eg increased numbers of collateral arteries; Vines, 1984), some of which in turn result in reduced circulation time, reduced heart rate (Andersen, et al, 1971; Kasch, 1976), lower blood pressure (but see Gettman et al, 1976), increased arterial pressure (reviewed in Cooper, 1989; Horton, 1981; Host and Hollmann, 1983), cleaner arteries, more efficient glucose metabolism (De Fronzo in Anon, 1983), and reduced respiration rate (Shephard, 1984). Exercise leads to reduced kidney function, renal blood flow falling by as much as 75% during strenuous exercise; and it is accompanied by inhibitory effects on most electrolytes (Na, Cl, Ca, P) and by protinuria (reviewed by Poortmans, 1984). Muscle mitochondria are increased in number (Holloszy and Coyle, 1984).
These physical changes suggest that exercise can be viewed as a body stressor, a beneficial stress. The animal literature confirms the idea that an optimal level of stress leads to an increase in an individual's adaptive responsiveness to subsequent stress. The early work of Denenberg (eg 1976) showed that mild stressors applied daily to young rodents produced increased adrenal capacity and a less reactive temperament in adulthood. As stressors become more prolonged (Konechi, 1975; Ottinger, Denenberg and Stephens, 1963) or more intense (Candland, 1977; Chamove, 1980), subjects often become more responsive to stressors, although curious temporal anomalies were reported (Denenberg, 1967; Ryan and Wehmer, 1975). From the animal research, several lines of evidence suggest that greater sympathetic nervous system (SNS) capacity and hormonal capacity are associated with more positive responsiveness towards stressful situations, with temperaments characterized by less anxiety and emotional re-activity (Candland, 1977; Chamove and Bowman, 1976). However, the few human studies on this subject do not support the same conclusion. As an example, students with high cold tolerance indicating high SNS response capacity rated themselves as more fearful, more "emotionally controlling", but as having a higher preference for emotional and suspenseful entertainment (Dienstbier, 1981).

The animal literature suggests a connection between the bodyweight research and anxiety level. Rat strains bred for high levels of emotional reactivity (Broadhurst, 1975; Imada, 1972) or strains that differed in emotionality levels (Chamove and Sanders, 1980) were shown to have higher body weights and to be less active than calmer rats. There has been no attempt to disentangle these correlations (Archer, 1975).

In conclusion there seems to be evidence that human and non-human primates normally spend a large proportion of the day in activity or work. When they do not, in zoos or in hospitals, abnormal behaviours develop. When given activities of a physical (and perhaps mental) nature, many of these behaviours are dramatically reduced.

**Behavioural Model**

Ismail (cited in Folkins and Amsterdam, 1977; also Ismail and Trachtman, 1973) has presented a general psychological theory which suggests that psychological and physiological changes occur when an individual confronts a challenge (eg an exercise programme) and masters it, although as many as 90% may drop out of exercise programmes. The suggestion of this theory is that challenge leads to self-control and the two become associated with pairing, although the stimulus response contingencies do not seem to be optimally timed to produce rapid learning. In fact one might predict that the preponderance of S-R pairings would be such that the challenge of the exercise programme becomes conditioned to stress during the early period of the programme. This prediction is supported by anecdotal reports of stress, pain, and failure. A reasonable inference from the argument of Ismail would be that in a shock-avoidance situation, an animal would not come to learn to connect the buzzer with the feared shock but instead would eventually pair...
the buzzer with a sense of accomplishment and subsequently seek out the shuttle-box situation. This is not the case.

It may be that continual exposure to the stressor plus successful coping, while not leading to approach towards the stressor, will lead to successful coping with other stressors when they do arise (e.g., Michael, 1957). However, it may also lead to helplessness in the individual that does not learn the coping strategy. Miller (1979) suggests that "controllability" is important in and also specific to those areas in which the experience has occurred. Support for the importance of controllability has been found (Canter and Canter, 1979; reviewed in Rodin, Rennert, and Solomon, 1980). White's view is slightly different; for him coping is "striving towards acceptable compromise" (1974 p 52). It would be interesting to compare dropouts from an exercise programme with those not having failed but at the same stage in the programme, on their responses to physical and psychological stressors. This might help separate out success and failure from the calorific expenditure variable.

The above review would support a competence interpretation for the beneficial effects of exercise. The maximal effects of exercise are found in the unfit, the anxious, the hospitalized, and the overweight. In support of Ismail, merely having control over stressors does lead to a reduced psychophysiological responsiveness to the stressor (Lundberg & Frankenheuser, 1978). Of course, it has been known for some time that success experiences in themselves lead to reduced anxiety levels and that failure experiences lead to increased anxiety (Gaudry, 1977). One might further expect success experience to be even more important in mentally handicapped populations (Chamove, 1984; Riese and Lobb, 1967). We must caution that different individuals have different coping styles (Lazarus, et al, 1974). Some deal with the stress directly by attack, withdrawal, or perhaps by preparatory behaviour. When direct action is not taken, other strategies may be used; palliative methods such as denial, psychological withdrawal, exercise, relaxation, self-stimulation, etc.

Others have stressed the importance of competence in behaviour (White, 1959; 1979). Bandura (1977) too has discussed the effect of placebos and other psychological procedures on "self-efficacy" (also Critelli and Neumann, 1984). Maslow (1971) described self-actualizers as being "involved in a cause outside their own skin, in something outside of themselves, ... working at something" (p 45). An ambitious longitudinal study attempted to assess the type of environment which leads to the development of competence. Multiple regression analysis identified several groups of experiences at 12-15 months of age that were highly correlated with achievement at three years. One of these was restriction of a child's activities. Children who spent as many as three or more hours a day "passing time", bored, unable to alter their circumstances, regularly confined to a small room, crib or playpen were consistently poor in the development of competence (White, Kaban and Attanucci, 1979).

If competence is important in mental health, then the work of White can be used to make predictions. For example, one of the striking and unexpected
findings from that study was the difference that firstborn status makes both in the behaviour of parents and in the subsequent development of high levels of competence in the children. For example, mothers spent twice as much time with firstborns as with laterborns. Even larger differences have been found in controlled studies with animals (Mitchell and Schroers, 1973). One might expect that this extra stimulation would lead to increased activity levels; also extra stimulation might act like the mild early stressors of Denenberg's rats, leading to an improved ability to cope with stressors later in life.

If general competence protects one from the effects of stress, and stress is important in the development of mental illness, then one would predict a lower level of mental illness in firstborns. A check of the literature showed that this is not the case in schizophrenia when comparing first-born with second-born individuals (Hare, 1967). Only in families of four or more was there an excess of last-born over first-born in schizophrenia (and also a poorer prognosis and greater severity); and this effect was limited to females and was not a strong one (Schooler, 1972). A more direct route could be inferred from the recent review of Stone (1983). If early stimulation leads to faster and greater responsiveness of adrenals and catecholamines to stress, then one would predict early stimulation would lead to a degree of protection against some illnesses.

**Catharsis Model**

Another mechanism for the beneficial effects of physical activity is suggested by the theory of catharsis. Here, performance of any energetic act is postulated to release pent-up aggressive energy, reduce tension, and reduce any remaining instigation towards aggression. This ties in with a theory of emotion put forward by Candland (also Plutchik, 1980) linking emotion and energy expenditure. He states that emotion is "experienced when sudden and extreme physiological readjustments occur, as they do when a sudden change in energy level is demanded" (1962, p 32). He continues, stating that subjective qualities of emotion come from (a) awareness of bodily changes in adjusting to a new energy level needed by the individual and (b) awareness of the stimulus situation and the set for response to that situation. Lazarus (1974) stresses different factors; he claims that for adaptive behaviour one needs (1) information, (2) internal organization, and (3) autonomy. One appraises one's situation with regard to mastery of needs (among other things), and emotion is the response to this appraisal. For Plutchik (1980) too, control is one important dimension in an individual's response to stress.

There are, however, many problems with energy theories of the motivation of any behaviour (Bindra and Stewart, 1966; Hinde, 1960). There is widespread agreement that the catharsis hypothesis is untenable for instrumental aggression (Konechi, 1975; Layman, 1971), but there is some support for an energy explanation of reactive aggression. Layman (1974) reviews research on aggression and sports participation, and she concludes that while "there is some evidence that exercise programmes may reduce ... aggression in mentally disturbed individuals" (p 53), most of the evidence suggests that neither exercise nor being a spectator at a competitive event reduces the
probability of aggression or even concern about hostile feelings. In fact sports-play, "rather than being opiative seems more overstimulative, ... touching off acts of collective violence" (Ingham and Smith, 1974, p 220).

Summary

It appears that there is consistent evidence from animal studies that exercise has immediate and long-term effects on behaviour. The reliable effects from these studies suggest that: Moderate exercise has short-term effects reducing aggression, inactivity, and abnormal behaviour; and long-term effects in reducing responsiveness to stress. Individuals seek out exercise, and when this is not available, abnormal behaviour is the result. The predictions and effects are compatible with a sociobiological interpretation of a biological need for exercise.

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Relaxation reduces disruption in mentally handicapped adults

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ABSTRACT. To assess the effects of modified relaxation training on subsequent disruptive behaviour, two groups of six non-institutionalized mentally handicapped adults were compared. At the end of 3 weeks training, those given relaxation training showed 71% more relaxation after relaxation sessions and 74% less disruptive behaviour later in the day, whereas controls who were only told stories showed no decrease; aggression and verbal disruption showed the most consistent effects. This suggests that modified relaxation is rapidly effective in inducing relaxation and in reducing disruption.

INTRODUCTION

Successful reintegration of the mentally handicapped into the community is hampered by agitated/disruptive behaviour (Heal et al., 1980). Disruptive behaviour is believed to be precipitated by tension and anxiety (Bijou, 1966; Peck, 1977; Zigler, 1966). Although relaxation has been successfully used to reduce anxiety in normal populations (Bernstein & Borkovec, 1973; Brown, 1977; Jacobson, 1938; Paul & Trimble, 1970; Wolpe, 1973), it has not been widely used with the mentally handicapped.

Although relaxation training has been shown to be successful for the treatment of psychomotor seizures (Wells et al., 1978), self-injurious behaviour (Steen & Zuriff, 1977), and phobias (Peck, 1977) in this population, studies on treatment of anxiety have been inconclusive. Five studies using physiological factors to assess anxiety have found some reduction of tension and anxiety from using relaxation, but these studies are methodologically flawed. Progressive muscle relaxation (PMR) reduced anxiety in mild but not moderate handicap (Vitale, 1983); EMG biofeedback training reduced anxiety in both mild (Harvey, 1978) and moderate handicap (Vitale, 1983); hypnotic relaxation reduced frontalis muscle tension in both mild and moderate handicap (Fabrikant, 1983); and combining PMR with EMG biofeedback reduced EMG levels in mild, moderate, and severe mental handicap (Frankenberger, 1980). But with the exception of this last study, the training methods used were ill-defined or there was no indication of assessment of relaxation.

Other studies have not shown reductions of anxiety with relaxation in the mentally handicapped, especially in the moderately and severely handicapped (Klein & Deffenbacher, 1977; Marholin et al., 1979; Putrer et al., 1977). Harvey (1979) suggested that it may be necessary to simplify the standard techniques of relaxation for use with the mentally handicapped.

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Two such modified forms of PMR, called abbreviated progressive relaxation (APR) (Bernstein & Borkovec, 1973) and behavioural relaxation training (Schilling & Poppen, 1983) have been shown to reduce anxiety immediately after training in individual mildly and moderately mentally handicapped subjects (Lindsay & Baty, 1986a, b; Rickard et al., 1984). Because these techniques focus on observable behaviours, they appear suitable for use with the mentally handicapped. However, there is no published evidence that anxiety is reduced at an interval after relaxation training has finished, or that disruptive behaviour is reduced as a consequence of relaxation training.

While several studies have incorporated relaxation into behaviour modification programmes to reduce undesirable behaviour, such as temper tantrums, bed wetting, masturbation, aggression and verbal threats (Small et al., 1978; Reese et al., 1984; Bott, 1979; Harvey et al., 1978), there is no evidence that relaxation per se was influential. Only three studies have used relaxation alone to alter disruptive behaviour, and all used institutionalized mentally handicapped individuals who displayed very aggressive behaviour (Frankenberger, 1980; Kenny, 1982; Steen & Zuriff, 1977).

There are no studies which used a well-defined relaxation procedure, adapted for use with the mentally handicapped, to reduce disruptive behaviour in non-institutionalized mentally handicapped adults.

**METHOD**

**Subjects**

Twelve subjects, 10 female and two male, were randomly selected from 38 clients identified by instructors and management staff as regularly showing disruptive behaviour in their 12-member work or activity group. Three with severe physical handicap, three who refused to participate, and one with extremely disruptive behaviour were excluded before selection from the 36. All attended Kerse Road Adult Training Centre, Stirling, Scotland, daily, but lived at home. Half (one male and five female) were randomly allocated to the experimental (relaxation) group.

Ages ranged from 19 to 55 years, mean \( M = 34 \); mental age as assessed by the British Picture Vocabulary Scale ranged from 3 to 17 years, \( M = 7 \), so subjects ranged from profound to mild mental handicap. The respective values for the relaxation and control groups were 19–45, \( M = 35 \); 22–55, \( M = 33 \); and 4–12, \( M = 7 \); 3–16, \( M = 7 \). All subjects were told that their work group activities were being recorded, and that they could leave the study at any time.

**Procedure**

Disruptive behaviour was identified by asking the instructors for behaviour which interrupted the work or activity of clients; they were then asked to rate on a 10-point scale how disruptive each of the 17 behaviour categories were. These 17 items were categorized into four which were the basis for analysis: (1) Aggressive—kicking, biting, threats, hitting objects etc.; (2) Verbal—shouting, swearing, interrupting instructor; (3) Movement—pacing, agitation, restlessness; and (4) Other—refusal to
work, distracting other group members, crying. Based on the ratings by the instructors, these four categories were rated 7, 5, 3 and 2, respectively, in terms of the degree of disruption.

The procedure consisted of four essential components: (1) Baseline recording of disruptive behaviour was followed by (2) relaxation training for half the group and story reading for the other half; during this period (3) relaxation levels were recorded before and after the training period for both groups, and (4) disruptive behaviour was recorded during the day following the training. Finally, there was a period of follow-up 12 weeks after training had ended.

In all parts of the study, each subject was individually observed in their usual work/activity groups within the centre for 45-min sessions, at one of four different times of the day, following the training period. For analysis purposes, the data were converted to ‘frequency per 30-min session’. Note was taken of the day of the week to control for post-weekend effects. Training sessions took place on weekdays at 10 00, 10 15, 13 00 or 13 15 h in groups of three in a quiet room 4·6 x 6·9 m, and lasted for 15 min.

Baseline consisted of a total of six observation sessions for each subject taken over five different days. These six sessions were combined into three sessions for analysis: beginning of the week, middle of the week and end of the week. This was done so as to account for expected post-weekend effects.

Relaxation training consisted of 12 training sessions, four times a week over 3 weeks using abbreviated progressive relaxation (APR) as devised by Lindsay & Baty (1986a). Following their procedure, instructions are simple, concentrating on observable behaviour, the actions are modelled by the instructor, and manual prompts are given when required. A pilot project had previously been conducted with five other clients, so the researcher (C.H.M.) was familiar to the subjects and in teaching APR.

Control condition followed the same format as the experimental relaxation training group, except that a story was read to subjects as they sat quietly. Except for the content of what was read to them, the conditions for this group were similar to those of the relaxation group. The following stories from Siderman (1970) were used: (1) Gingerbread Man; (2) Golden Headed Fish; (3) Princess and the Pea; (4) Rumplestiltskin; (5) Musicians of Bremen; (6) Little One Eye, Little Two Eyes, Little Three Eyes; (7) Three Little Pigs; (8) Shoemaker and the Elves; (9) Rapunzel; (10) Three Bears; (11) Hansel and Gretel; (12) Bluebeard.

Assessment of relaxation was carried out using a behavioural rating scale (Lindsay & Baty, 1986a). Subjects were observed in a random order at the start of and at the end of the relaxation or story reading period. How tense the subjects appeared, their breathing rate, and other observable indications of tension or relaxation were estimated on a 10-item checksheet. All subjects were recorded on the first-day of training, on four randomly selected intermediate days, and on the final training day; this gave total relaxation scores for each subject, two per week for 3 weeks, both before and after the training session.

Assessment of disruption was carried out for 45 min starting between 10 min and 4 h following the end of the training sessions. Subjects were observed three times each week, at different times of the day, and on different days of the week; the precise
value for each of these variables was determined randomly. All subjects were observed on all Mondays to assess the effects of two days without training.

Each incident of disruptive behaviour was recorded in 10-s intervals with an arbitrary maximum value of 20 intervals per incident.

Instructors, who did not know the treatment given to the subjects, daily recorded the level of disruptive behaviour shown by each subject. They used a simple 10-point scale from 'not disruptive' to 'extremely disruptive'.

The follow-up study consisted of four observation sessions on 2 different days in 2 consecutive weeks, 3 months after the completion of the original study. Because of extensive changes within the centre, only three relaxation and three control group participants could be observed under similar conditions to that at the time of the original study.

Analysis of results used an analysis of covariance of the form Groups (2)×Days (3)×Weeks (4), with one covariate, that of mental age. This analysis was carried out on the overall scores of total disruptive behaviour and then on each of the four disruptive categories separately, subsequent to significant effects in the first analysis. A further analysis was done using weighted disruptive behaviour scores; here each value was multiplied by the weighting value described above. Follow-up data were not included in the analyses. Finally, an analysis of variance was performed on the relaxation scores over the six sessions, using the data from before and after the training sessions.

A Pearson product moment correlation coefficient between instructors' rating of disruption of each subject and observed disruptive behaviour was calculated to give confirmatory and independent evidence of effects.

One subject from each group was discarded for analysis, one because she was ill for a week during treatment and the other because she showed almost no disruptive behaviour at baseline and throughout the study.

![Total disruptive behaviour](image)  
**Fig. 1** Change from baseline in incidents of total disruptive behaviour over nine treatment and two follow-up sessions (three sessions/week) for the relaxation (n=5) and control (n=5) group.
RESULTS

The first analysis of covariance on total disruptive behaviour over the 12 sessions showed a significant difference between the relaxation training group and the control group. There were significant Groups×Weeks (F(3,24)=4·5, P=0·01) and Groups×Weeks×Days (F(6,48)=2·3, P=0·04) effects, showing the greater beneficial effect of training in the relaxation group. This reduction in total disruptive behaviour from baseline is illustrated in Fig. 1 where the scores on days during the treatment were subtracted from the comparable scores during baseline in the same third of the week. The total disruptive behaviour in the experimental group showed a 74% reduction from a mean of 14·3 incidents in 30 min per subject during baseline to only 3·6 on the final day, while total disruptive behaviour in controls rose slightly from 10·2 to 10·9.

Separate analysis on each of the four categories of disruptive behaviour showed a significant Groups×Weeks effect in verbal behaviour (F(3,24)=3·3, P=0·03) and a Group effect in aggressive behaviour (F(1,3)=10·2, P=0·04). When comparing behaviour on the three baseline days with that on the final day of training, verbal disruptive behaviour significantly reduced by 55% in the relaxation group from 5·6 to 2·5 incidents in 30 min, while there was a substantial (50%) but non-significant increase in the control group from 3·6 to 5·4 as a result of the story-telling sessions,

![Graph](image-url)
while the two groups differed significantly. Aggressive disruptive behaviour significantly reduced from 1·6 incidents in the relaxation group to 0 on the final day, whereas in the controls it rose from 1·9 to 4, a significant between-groups difference. Movement disruptive behaviour was significantly reduced by 75% from 5·6 to 1·1 incidents in the relaxation group, and showed no change in the control group; the between-groups difference was not significant. Other disruptive behaviour was significantly reduced from 3·4 incidents to 0 in the experimental group and reduced from 4·1 to 0·8 in controls, again no difference between and two groups for this mildest form of disruption.

Relaxation scores showed large differences between the two groups. As can be seen in Fig. 2, the relaxation group showed significant linear reductions in relaxation both before and after the relaxation sessions over the 3 weeks of training, while the control group did not change. The analysis revealed significant effects of Group (F (1/8) = 52·9, P = 0·0001), Group x Time (F = 69), Group x Sessions (F = 137), and Group x Time x Sessions (F (5/40) = 18·8, P < 0·0001).

The relaxation scores showed an increase on the last day from day 1 in the relaxation group of 48% just by entering the treatment room and an increase of 62% for scores after the 15-min relaxation treatment. Comparable scores for the control group read a story were a 4% reduction and an 11% increase. The total increase in relaxation score from before relaxation on day 1 to after relaxation on the final day was 71% in the relaxation training group (also Kenny, 1982).

The analysis of the weighted total disruptive scores was similar to that of the unweighted scores and so will not be discussed further. Also the covariate of mental age was found not to be significant on any of the analyses of covariance.

The correlations between the subjective ratings by four instructors of total disruptive behaviour and observed levels of behaviour were high, +0·78. Also high were the instructors’ ratings of change in behaviour between baseline and the final day, r = +0·86, supporting the observational data.

DISCUSSION

These results clearly showed that Abbreviated Progressive Relaxation significantly and substantially reduces disruptive behaviour in mentally handicapped adults. All four categories of behaviour measured were reduced by relaxation, and two of them (verbal and aggressive) were significantly different from the control story-telling group. The greatest decrease was for aggression and other disruptive behaviour which were eliminated for the rest of the day. Where a few studies have shown relaxation when included with other techniques to reduce very aggressive behaviour, the present authors have shown that, when used alone, it can not only reduce aggression, but also other disruptive behaviour which is socially inappropriate and inhibits integration into the community. Like Kenny (1982), most effects were seen by week 2.

Unlike that found in other studies where training sessions were infrequent, the effects of daily training on relaxation in this study were immediate and also cumulative. Also unlike previous studies, the authors found that APR training alone was equally effective in all levels of non-institutionalized mental handicap tested, in
Relaxation in mental handicap 405

both inducing relaxation and in reducing disruption, and had effects which lasted for the remainder of the day. This supports Harvey’s (1979) recommendation to simplify relaxation instructions in mental handicap.

Story-telling did not significantly change relaxation and did not significantly change the disruptive behaviour recorded here, although there was a trend for verbal behaviour to increase and for other behaviour to decrease.

Because there was no attempt during training to teach relaxation as a coping skill for use outwith the training room, the incidents of disruption recorded at the 3-month follow-up had returned to baseline levels. A reasonable extension of this study would be to teach relaxation for use as a coping strategy.

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Correlates of successful psychological treatment in general practice

A three-way study


Performance indicators for psychological therapies are difficult to obtain, and when they are estimated there is disagreement between patient, therapist and independent observer.2

Patients' self-report commonly presents a more conservative assessment of treatment efficacy than other ratings. While prognostic indicators of the response to psychological treatment have been difficult to determine,3,5 contact with a psychologist does lead to objectively-assessed improvement, for example decreases in the medication for patients.6

The present study was designed to look at the intercorrelation of four major variables:

1. success of psychological treatment viewed by the patient, the clinical psychologist (CP) and the general practitioner (GP),
2. the duration of therapy in terms of number of appointments, span of treatment and the average length of individual sessions,
3. compliance with the clinical psychologist's treatment recommendation, and
4. patient use of medications and other substances.

We selected 61 patients presenting with one of three main problems — anxiety, depression or phobias; half had finished treatment approximately three months earlier and half some six months earlier. Half had been treated by one therapist (WAJ) and half by another (KGP).

Patients were posted a questionnaire containing eight questions, answered on a 10-point continuous scale. Questionnaires were returned without names but coded to identify individuals. Half of those sent out were returned (30).

Each GP (n=36, 26 responded) was sent a similar questionnaire for each patient.7 From the referral letter and the clinical notes, 30 variables were extracted.

Measurements of severity taken from the referral letter included an assessment by an independent rater (ASC), the length of the letter, the total number of adjectives used, the number of words about the problem, the number of symptoms mentioned, and the number of direct comments about severity.

Severity was rated from the psychologists' initial reply letter and from the number of symptoms listed in the GP's case notes.

Pearson product multiple-correlation was performed on all 58 variables. Results describe correlations in which there was both two-tailed significance with a P<.01 and correlations at P<.05 for each therapist when analyzed separately.

Results showed that greater improvement, as assessed by patients at follow-up, correlated with a greater number of symptoms reported in the psychologists' case notes of the first session (r=.63), longer individual therapy sessions (r=.50), reported continued use of treatment techniques taught (r=.54), high patient compliance with therapist suggestions (r=.71), and low use of alcohol, nicotine (r=.58), or medication (r=.54).

Patients longest on medication reported their problem to be the most severe both at the end of treatment (r=.68) and at follow-up (r=.58), and they were seen too infrequently (r=.70). While those reporting using more alcohol or nicotine felt they had improved the least (r=.57), were worse after therapy (r=.55), felt they had been seen too infrequently (r=.86), and sessions had been too short (r=.84).

GP assessment of success of treatment did not agree well with the patients' view of success (r=.60), while agreement between therapist and patient about problem severity was moderately high (r=.53), shown in Table I.

This suggests that GP evaluation is monitoring something different from that of the patient and the CP. The correlation between GP and patients' severity ratings was .12 before treatment, .03 after treatment, but up to .20 at follow-up. Attempts to correlate severity with objective attributes of referral letters were unsuccessful (Table I).

The GP view of severity at follow-up was highest in patients from higher social classes (r=.48), in those patients with a low self-rated rating of severity before treatment (r=.57), and with high alcohol intake (r=.51). GPs who made more frequent use of psychological services referred those who were currently on medication for longer (r=.54) and who reported more marital problems (r=.45).

Longer therapy sessions were seen in those still using therapy techniques (r=.58) and were associated with a shorter span of treatment (r=.34), fewer appointments attended (r=.36), more symptoms in the GP's case notes (r=.47), a pattern of missed appointments earlier in treatment (r=.37), and low caffeine and nicotine consumption (r=.46, .48).

Poor patient compliance with the therapists' recommendations as measured by tasks tried
or completed was associated with rarely going out of the home (r=-.39), previous psychiatric referral (r=.34), more psychological problems (r=.46), the absence of marital problems (r=-.61), greater patient age (r=-.86), and a high rating by GPs' of severity before (r=-.60). It was also associated with more appointments offered and attended (r=-.52, .45) and with shorter treatment sessions (r=.69).

Successful intervention was characterised by longer individual therapy sessions, by fewer appointments offered and attended and a shorter span of therapy.

Our results mitigate against using unduly short individual treatment sessions which psychologists in primary care may believe cost-effective and fool pressure to adopt. Those who received longer treatment sessions were more likely to comply with instructions and to continue using techniques in turn associated with maintenance of therapeutic gains. Offering fewer but longer appointments may be a cost-effective method of providing psychological treatment in primary care.

The use of substances and psychotropic medication was associated with poor response to and satisfaction with psychological treatment and poor compliance with treatment recommendation.

This supports the idea that patients who receive psychological treatment at an early stage respond better, and that becoming dependent on psychotropics may lead to less response to psychological treatment when eventually offered.

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Paradox, reprimand and extinction in adults with mental handicap

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ABSTRACT. To assess the efficacy of paradoxical directives, levels of challenging behaviour during 2 weeks of paradox, reprimand and extinction were compared with baseline levels in four adults with mental handicaps attending a day centre. Paradox was the most effective procedure for reducing the frequency and severity of challenging behaviour by an average of over 70% by the end of 2 weeks and up to 90% in certain subjects; extinction was least effective. Paradox was most effective with more defiant subjects, when staff rated treatment success as low, when improvement using extinction and reprimand was poorest, and in reducing aggressive behaviour. The present authors suggest the overjustification effect offers an explanation for the effects of paradox.

INTRODUCTION

The essence of paradox involves prescribing the very behaviour that the therapist wishes to reduce. Paradox may also involve reframing and restraining, but these elements are not essential to it. Reframing reinterprets the behaviour in a positive way; in restraining, the therapist pretends to counter any change to more positive behaviour. There are compliance- or defiance-based paradoxes (Rohrbaugh et al., 1981). In the former, change occurs when the client tries to obey a paradoxical prescription but cannot, or tries and realises its absurdity; the latter is based on the assumption that the client will oppose the paradoxical instruction. While symptom prescription appears to be the essence of paradox, it is not clear why paradox works.

Explanations of other techniques that also use symptom prescription do not seem to offer as convincing an explanation for different types of paradox. (1) Theorists using massed practice suggest that such practice generates reactive inhibition which interferes with the learned habit, such as a tic (Teichman & Eliahu, 1986). (2) Those using implosion would suggest that imagining the fearful event until extinction occurs to all cues in the avoidance serial cue hierarchy would make associations between the stimulus and the response less likely (Greenberg & Pies, 1983; Weeks & L'Abate, 1982) and would increase a sense of self-mastery (Chamove, 1986; McPhail & Chamove, 1989). Implosion is similar to that of stimulus satiation (Ayllan, 1963) and Gestalt therapy's exaggeration technique (Enright, 1970). Whereas, with both of the above, some forms of paradox require no practice at all. (3) Erickson's directive
therapy suggests that the client cannnot use a symptom to control social interaction once the behaviour is encouraged (Haley, 1973) and it undermines defiance (Soper & L'Abate, 1977). It cannot explain compliance-based paradox.

Orthodox learning theory is unable to explain the effects of paradox in which positive reinforcement, if that is what it is, leads to reduction of behaviour. The present authors propose another explanation for paradox, the overjustification effect (OJE). The OJE suggests that the use of extrinsic pressures or reinforcement decreases subsequent intrinsic motivation to engage in a behaviour. The effect has been shown in a variety of populations from pre-school children to adults (Condry, 1977; but see Ogilvie & Prior, 1982, for mental handicap). The present authors believe that the OJE can also explain behaviour observed in monkeys (Harlow et al., 1950) where food reinforcement leads to a reduction in behaviour. High-interest tasks are particularly susceptible to the OJE (Deci, 1971) and surveillance augments the effect (Lepper & Green, 1975). For a maximum OJE to occur, the therapist should tell the subject to continue the behaviour in the same form but change the stimulus which begins the behavioural sequence, thereby altering subject choice. In both paradoxical therapy and the OJE, and probability of reoccurrence of the behaviour is reduced.

The OJE may not be a complete explanation for the treatment condition of paradox. In the human OJE studies, the rate of behaviour (studies are always on desirable behaviour patterns) actually increases while reward is present and only decreases after external reinforcement is withdrawn (e.g. Deci, 1971). Under a paradox condition, reduction in the rate of undesirable patterns occurs while the directives are being given, and also after they have stopped. The present authors argue that the directives are an extrinsic pressure, and it is likely that the therapist’s directives are not interpreted by the client as a reinforcement in the same way that sweets are by children.

Paradox has been used to treat a variety of problems (Stanton, 1981) and has been shown to be useful with children (Jessee & L'Abate, 1980). However, the present authors could find no studies which objectively assessed its efficacy, none comparing it with other behavioural techniques, and only one published study which used it in mental handicap. Bergman (1980) described six case studies in which paradox was effective in reducing disruptive behaviour in adults with mental handicap, but he used no objective measures, comparison techniques or statistical analysis.

The use of paradox in people with a mental handicap has not been recommended (Jessee & L'Abate, 1980), although no data are given. Possibly they think that low intelligence excludes the capacity for insight, but Haley (1976) suggests that insight is not necessary for paradox to be effective. The present authors think paradox would be especially useful in mental handicap where frequently (1) other techniques have been tried and failed, (2) subjects are defiant as it avoids confrontation, and (3) intrinsic motivation is high, as discussed above.

This study is the first to compare paradox with extinction and reprimand (last two reviewed by Kazdin, 1980), and uses a within-subjects design to assess the relative success of paradox in reducing the frequency and severity of challenging behaviour in adults with mental handicap.
Subjects
The four participants were classified as having a mental handicap and, while living at home with their parents were attending an adult training centre 5 days a week. Activities took place in groups of eight to 10 and 130 people attended the centre. The ages of the four subjects ranged from 17 to 31 years, and their age equivalents from 4-0 to 7-7 (Vineland Adaptive Behaviour Scales); one was female. All were selected as showing high levels of challenging behaviour as defined by the staff. All were believed to understand the verbal communication required by the experimental manipulations.

Subject 1 (age equivalent 7-7 years) would swear, and was verbally aggressive to others. Verbal challenging behaviour occurred 6-3 times per day during baseline. He would leave the room without permission and wander around the class; movement challenging at 3-4 per 4 h during baseline. Subject 2 (5-7 years) was hyperactive, and was verbally aggressive, shouting, swearing and threatening violence towards staff (verbal=15-4, aggressive=3-8, movement=5-9 at baseline). Subject 3 (4-0 years) had a verbal tic, usually wandered around the centre and was seemingly involuntarily aggressive in conversation in a manner comparable to Tourrette's syndrome (verbal=13-5, aggressive=2-8, movement=5-4 per day). Subject 4 (4-0 years) had cerebral palsy, and engaged in rocking, hand-flapping, echolalia and inappropriate conversation (verbal=21-8, stereotypy=32-8 at baseline).

Procedure
Subjects were observed continuously for 2 h every morning and 2 h in the afternoon, Monday to Friday for 9 weeks, giving a total of 180 h observation for each subject. The four instructors who normally worked with the clients observed for 75% of the time, one author (VEW) carried out the remaining 25% of the behaviour observations balanced equally across all subjects, and all observers carried out experimental interventions and data recording during the observations under normal working conditions at an adult training centre. Subjects were in separate work groups and were observed by one staff member only. We excluded subjects who showed any physical aggression or severe verbal aggression.

During baseline, the instructors were asked to show the same response to all challenging behaviour patterns as they normally did, which was commonly reprimand; during extinction, instructors were asked to ignore all challenging behaviour; during reprimand, instructors were asked to give a mild reprimand to subjects when they were engaging in challenging behaviour; and during the condition of paradox, instructors were asked to encourage the subjects to continue with challenging patterns and also to increase the frequency and severity of behaviour. Instructors were also asked to avoid sarcasm and to give subjects a brief explanation of why they should continue with the challenging behaviour. For example, a man was told, 'Show me that again—I'll bet nobody gets bored with you always sticking pens in your ears.' This defiance-based directive led to the man immediately removing the pens from his ears and returning to the work he had previously been doing. In addi-
tion, each subject was rated by the experimenter and by staff for level of aggressive defiance in response to requests; and after each condition, staff ranked the three techniques as to the level of comfort they felt and the level of success of each.

Measurement

Challenging behaviour was divided into five mutually exclusive categories, from the factor-analytic work of Aman et al. (1985): (1) Verbal, such as shouting, swearing and verbal tics; (2) Aggressive, including verbal threats and physical aggression towards persons or objects; (3) Movement, such as leaving the room without permission; (4) Stereotypies; and (5) Other, such as belching or refusing instructions. The frequency of challenging behaviour patterns was recorded whenever they occurred, and the severity was noted on a scale from very mild (1) to very severe (5) at the end of 2-h observation blocks. The frequency of continuous behaviour patterns, such as rocking, was recorded once every 5 min.

Reliability

Inter-observer agreement was calculated on frequency data using Pearson Product Moment correlation coefficients between each of the four members of staff and the experimenter over a one-hour period, and ratings compared every 5 min of the hour. Correlation coefficients ranged from 0.88 to 1.0, a high agreement. The present authors felt frequency to be the better of the two measures, as it was recorded continuously throughout the observation period and not just rated at the end of the observation sessions.

Experimental design

The study followed an ABACAD design, with A as the baseline. Data were collected for each subject for a week of baseline alternating with 2 weeks of one of the experimental conditions; the order of conditions was randomised separately for each subject and then balanced. For ethical reasons, during all conditions, instructors were asked to positively reinforce subjects by praising (Deci, 1971) appropriate behaviour whenever it was seen.

Analysis

Evaluation of the results was by analysis of variance (ANOVA), employing the BMDP statistical package. A preliminary ANOVA compared baseline after each treatment condition and the baseline before any treatment. When this was found not to show significant differences, the baselines were combined into one for subsequent ANOVAS. The first ANOVA was a 4 (experimental conditions) × 5 (days) × 5 (behaviour) × 2 (time of day) × 2 measures (frequency/severity), where all the factors were repeated measures. The days factor was composed of 2-day blocks for the experimental conditions, combined to reduce day-to-day variability. Because of the small number of subjects, alpha was set 0.05 and was two-tailed. As stereotyped behaviour only
occurred in two subjects and 'other' was also infrequent, for analysis the two categories of stereotypy and 'other' were combined. Following significant results, a Dunnett's test was used to compare baseline with each experimental condition and a matched-sample multiple t-test compared the conditions with one another. Because behaviour varied so much between subjects and because of the small number of subjects, ancillary analyses were carried out on data from the individual subjects. The results of these four analyses should be treated as descriptive rather than inferential.

Pearson Product Moment correlation coefficients were then computed to assess prognostic indicators. These were age, age equivalents, sex, inter-observer reliability ratings, staff self-comfort ratings, staff success ratings, and per cent improvements from baseline of frequency and severity of behaviour. With only four subjects, a coefficient of 0.95 was needed for statistical significance, only one reaching that level. Consequently, only suggestive correlations above 0.7 accounting for 50% of variance are discussed below.

**RESULTS**

All three of the experimental conditions significantly reduced total challenging behaviour from that seen in baseline; the reduction was greatest for paradox, and the reduction was greater as days progressed (illustrated in Fig. 1). This was revealed in a significant condition effect in the ANOVA \((F(3,9)=5.4, P=0.02)\), followed by a significant Dunnett's test; and a significant effect of days in the ANOVA \((F(4,12)=3.3, P<0.05)\), which was strongly linear in form. Multiple t-tests showed that extinction and reprimand did not differ from one another \((t(7)=1.3)\), but that paradox was significantly better at reducing challenging behaviour than either extinction \((t=2.3)\) or reprimand \((t=2.4, P<0.025)\).

![Fig. 1 Stacked graph of mean percentage change from baseline for total challenging behaviour over all 10 days of the three treatment conditions. Baseline values were a mean frequency of 15.3 per person every 2 h (+SEM=4.4), and a mean rating of 2.0 per person (+SEM=0.4) for severity.](image)
Paradox, reprimand and extinction 379

Table 1 Percentage change from baseline of four behaviour categories (frequency plus severity). Positive scores indicate improvement, that is a reduction in challenging behaviour over the 10 treatment days. The baseline rate reflects frequency per subject per session (2 h) and severity rating

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Extinction</th>
<th>Reprimand</th>
<th>Paradox</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Severity</td>
<td>Frequency</td>
<td>Severity</td>
</tr>
<tr>
<td>Verbal*</td>
<td>11</td>
<td>40*</td>
<td>51*</td>
<td>7-2</td>
</tr>
<tr>
<td>Aggression*</td>
<td>-6</td>
<td>34*</td>
<td>56*</td>
<td>1-3</td>
</tr>
<tr>
<td>Movement*</td>
<td>-3</td>
<td>5</td>
<td>27*</td>
<td>2-4</td>
</tr>
<tr>
<td>Stereotypy</td>
<td>22</td>
<td>-4</td>
<td>54</td>
<td>8-6</td>
</tr>
<tr>
<td>Other*</td>
<td>54*</td>
<td>18</td>
<td>42*</td>
<td>1-6</td>
</tr>
<tr>
<td>Total*</td>
<td>12*</td>
<td>25*</td>
<td>42*</td>
<td>13-9</td>
</tr>
</tbody>
</table>

*P<0-05, indicates significant changes from baseline.

There was no significant interaction of conditions with the two measures of disruption: Paradox was better than reprimand which was better than extinction in reducing both the frequency and severity of challenging behaviour from baseline, frequency scores being 38, 32 and 15%, and severity scores being 44, 19 and 9% less than in baseline, respectively. The advantage of paradox over the other two forms of therapy was greater for the severity measure than for frequency. As can be seen in Table 1, the percentage reduction using reprimand was twice that of extinction, and the reduction using paradox was over 1-5 that of reprimand. By the final 2 days of the experimental conditions, the frequency of challenging behaviour was reduced by 71, 45 and 34% when using paradox, reprimand, and extinction respectively; for the severity measure, the corresponding values were 73, 41 and 11%.

When comparing the week of baseline before any treatment with the week periods following the treatments, there was no significant difference, the mean values being very similar. This enabled us to combine all these no-treatment weeks into one, which we called baseline. This result also indicates that the treatment effects did not persist for long in the absence of staff treatment.

There was a significant interaction of treatment conditions and behaviour \((F(9,27)=5-4, P=0-0003)\) (see Table 1). The results of a subsequent ANOVA looking at the four different behaviour categories with comparisons of each condition with baseline are shown in Table 1. Paradox was significantly better than ignoring verbal, aggressive and movement behaviour, and was better than reprimand for movement and other behaviour.

Separate individual-subjects ANOVAs showed significant effects of conditions for each of the four people. Paradox was the most effective at reducing the frequency of challenging behaviour for three, and at reducing the severity of challenging behaviour for all four of the subjects. Over the four subjects, the frequency of challenging behaviour was reduced from between 65 and 90% by the last 2 days.

From the Pearson correlations, those subjects with the highest mental age showed the greatest improvement during extinction \(r=+0-70\) and reprimand \(r=+0-84\) but
not during paradox, \( r = +0.11 \). High age equivalent was positively correlated with improvement of severity \( (r = +0.90) \) but negatively with improvement of frequency \( (r = -0.60) \) during paradox. The two subjects with lowest mental age also were those showing stereotypies, behaviour likely to have high intrinsic motivation (Berkson & Mason, 1963). Experimenter ratings of the aggressive defiance of subjects were not correlated with improvement during extinction or reprimand \( (r = +0.15, +0.04) \), but were during paradox \( (r = +0.76) \).

The staff rated extinction as least, and reprimand and paradox as equally comfortable for them to use. Reprimand was rated as more comfortable with low defiance subjects and paradox with high-defiance subjects \( (r = +0.70) \). Paradox is claimed to work best with high client resistance (Andolfi, 1967; Selvini-Palazzoli et al., 1978). The more comfortable the staff were with paradox and reprimand, the greater the improvement \( (r = +0.90, +0.74) \). Perhaps it is surprising that staff ratings of the success of paradox and extinction were negatively related to actual success \( (r = +0.56, -0.46) \), whereas with reprimand the ratings were positively correlated, \( r = +0.44 \), although paradox and reprimand were rated equally effective by staff.

Whereas there were high positive correlations in the improvements of the severity of challenging behaviour between the three treatments \( (r = +0.78, +0.93) \), the same was not true for frequency measures. Improvement during extinction and reprimand were positively related \( (r = +0.65) \), but the improvement shown by subjects during paradox was negatively correlated with that seen during reprimand and during extinction \( (r = -0.97 \) and \(-0.47, \) respectively).

**DISCUSSION**

Although all conditions reduced challenging behaviour from the level seen during baseline of approximately eight incidents per hour, over the two treatment weeks, extinction was the least effective. It reduced the frequency by only 17% and severity by 9%, reprimand was significantly better at 31 and 17%, but paradox was the best in reducing both the frequency (40%) and the severity (46%) of challenging behaviour. It seems that paradox can alter behaviour in those subjects who do not show behaviour change in response to extinction and reprimand techniques, but having only four subjects makes such conclusions tentative.

There is evidence to suggest that the less a subject expects a stimulus, the more effective is the stimulus as a punishment (Hugdahl & Ohmans, 1977). Staff all claimed to have used extinction and reprimand before the study, and were observed to do so during baseline, but none had used paradox. However, if the superiority of paradox was solely due to its novelty then one would not expect paradox to become more successful as time progressed.

The common explanations for the success of extinction is that staff attention is withdrawn. Following from this, one would predict that paradox would be ineffective since attention—of an even more positive nature—is still contingent on the behaviour. These opposite effects of attention may account for the negative correlation between effects in extinction and those in paradox. Subjects 3 and 4 showed the least improvement during extinction, the former’s total challenging
behaviour actually increasing by 33% from a baseline of 22 episodes per day. In the setting the present authors used, the members do not have much individual contact with staff; therefore, withdrawal of attention would be less salient to the subjects and could account for the relative ineffectiveness of the extinction procedure. The success of extinction is believed to be related to its attention-attracting powers. If stereotypy is a means to achieve an optimal level of stimulation (e.g. Berkson & Mason, 1963), then ignoring would make subjects even more reliant on self-stimulation. In the two subjects whose challenging behaviour was mostly stereotypy, both showed improvements during paradox (44 and 36% improvement, respectively). Assuming stereotypy is intrinsically motivating behaviour, and that paradox is comparable to the OJE in reducing intrinsic motivation, this would explain why paradox worked so well in these two people. OJE is most effective with high interest behaviour, as one would believe stereotypy to be (Deci, 1971). Where intrinsic motivation was presumed to be high and defiance was high and mental age was low, paradox was very effective.

The female subject had the lowest age equivalent and showed a high frequency and severity of rocking. When rocking normally, she would often smile and laugh; when under a compliance-based paradoxical directive to rock for longer and more vigorously, she did not smile or laugh and would often stop and say to herself, ‘Now you’re not to rock—sit nicely’, something her mother would say. The more pressure put on her to rock by the experimenter, the more resistant she appeared to become, and both the frequency and severity of her stereotypies decreased.

The use of paradox has not been objectively assessed before in this population group. Here it has been assessed in comparison with extinction and reprimand techniques and was found to be superior in reducing challenging behaviour over 2 weeks of treatment. The behavioural gains were not maintained after the treatment was withdrawn. While not the easiest technique to use or not perceived by staff as the most effective, it is promising for use in a population where some behaviour modification is desirable. It’s use is more compatible with self-advocacy in that it encourages people to take responsibility for their own behaviour. The use of paradox in mental handicap may also illuminate the role of defiance and intrinsic motivation in a non-laboratory setting where the overjustification effect is commonly studied.

Two possible reasons for the effectiveness of paradox can be suggested: (1) it removes some of the self-motivating factor from self-motivating behaviour patterns such as stereotypy by attributing an external reinforcement to the maintenance of the behaviour; and (2) it allows self-expression in a situation in which compliance is expected and such control often expressed in behaviour such as defiance.

An anonymous reviewer suggests an alternative explanation that ‘what is important is (a) the interruption of behaviour by intruding (presumably paradox was the most intrusive) and (b) the aversiveness of intrusion. In this case, ignore equals allows escape equals reinforcer, reprimand equals brief aversive, and paradox equals sustained aversive.’

ACKNOWLEDGEMENTS

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Moodie, E. Orr and A. T. C. Fiestner for comments on the manuscript. Consent was obtained from the subjects for observation. The study received ethical approval from the Central Region Social Work Department, Kerse Road Adult Training Centre, and Stirling University Psychology Department.

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Communication in Television Soaps

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Television soap operas are enthusiastically watched by many and are likely to provide models of social interaction. In a preliminary analysis of all 13 English-speaking programmes on Scottish television, just over 50% of the total number of interactions demonstrated poor relationship skills, and these skills were more prevalent (66%) in the most popular and the British productions. Over all the programmes unhealthy forms of hostility, power, and fear occurred twice as frequently as healthy assertive patterns of communication.

As Western society has changed, a person spends less time in an extended family and in the small, stable groups where they can observe the intimate interactions of a variety of relationships. Novels, magazines, and television, all of which are concerned with interpersonal problems and relationships, provide possible substitute models of social interaction (Downing, 1974; Buckingham, 1987). It is apparent that the use of these models may be even more prevalent in children (Eron, Huesmann, Fischer, & Mermelstein, 1983; Fishbein, 1984). Certain television dramas do not appear to require the willing suspension of disbelief, and people react to them in many ways as if they were portraying real events (Hobson, 1982).

Although the soap opera, a term coined as a result of the initial sponsorship by soap powder manufacturers, is now one of the most popular types of programme (Anon., 1989), there is surprisingly little research on certain aspects of their content. The few published studies involve asking people why they watch soaps, whether they think them realistic, what soaps tell the viewer, and the correlation of behaviour on soaps with behaviour in the community, specifically suicides (but see Livingstone, 1987). Cantor and Pingree's (1982, p.84) speculation that soaps may be potentially "emotionally hazardous because of the continual sorting and resorting of relationships" appears not to have provoked published research.

Soap opera writers have contended that part of their goal is to teach the lessons of life to their audiences (Cantor & Pingree, 1983). In order to verify the accuracy of this contention and attempt an evaluation of these lessons of life, it is important to describe and categorise the relationships portrayed. Family Therapy in general and Assertiveness Training in particular set specific criteria for healthy, desirable interaction within the context of therapy (Textor, 1989). If soaps reflect life, we might expect there to be a balance between two forms, with a predominance of healthy assertive interaction over unhealthy spiteful communication. And if they teach lessons of life, one lesson might be that healthy assertive forms are more effective. The purpose of this preliminary study is to measure the relative occurrence of different forms of communication from the perspective of clinical psychology and assertiveness training.

**Method**

All 13 of the English-speaking soaps presented on Scottish television during the last 4 months of 1988 were selected for study; 5 were made in Britain, 5 in Australia, and 3 in the United States of America. Table 1 gives details of title, time of day when shown, and estimates of their popularity (Anon., 1989). Over 8 to 16 weeks, extracts of between 3 and 10 min were chosen randomly from episodes (range 16 to 52) of each soap; these lasted a total of 3 hours on average for each soap. They were recorded onto a video recorder for analysis. The proportion of time recorded reflected the total viewing time per week of the British population. A total of 27 hours of interactions were analysed by one rater, P.M., after extensive discussion and instruction from a therapist who had used assertiveness training, A.S.C.

Family therapists teach healthy interaction, and these criteria were used to appraise the interactions. Behaviour categories were devised from several Family Therapy texts (especially Nelson-Jones, 1986; Satir, 1985) and from factor analyses of behaviour (especially Chamove, Eysenck, & Harlow, 1974: Hinde, 1979). "Interactions"
were divided into five behavioural categories, which were further subdivided into positive/negative and the negative into direct/indirect communications, the former being the more healthy in both categories. Examples of direct and indirect communications are respectively: "I don't like your shoes" and "You're not wearing those shoes again." Positive communications were assertive sentences which express the intentions of emotions of the person with minimal evaluation; whereas negative communications commonly have a component of negative evaluation.

The 5 behavioural categories used were the following:

(1) Hostile—composed of either assertive (positive, K = .89) or aggressive (negative, K = .92) components; examples were respectively "Doing that annoys me," and "You are mean." (2) Affiliative—composed of either assertive care-seeking and care-giving (K = .87) or manipulative (K = .91) components; such as "That makes me feel good," and "Couldn't you even have sent me a card?" (3) Power—composed of either assertive dominating (K = .81) or pressuring (K = .82) components; as in "I make financial decisions here," and "You little worm." (4) Fear—composed of assertive submissive (K = .89) or denial (K = .86) components; for example "I am afraid," and "How are you going to fix this mess?" (5) Neutral—such as an observation about the weather (K = .73). Oral material, intonation, gestures, and gaze were all considered in the assessment of interactions.

Interactions were declarations by a person bounded by discourse of others. If statements contained more than one category, all were recorded. Raw data was transformed into percentages of each soap's total interactions before statistical analysis. Analysis of variance was used to compare differences between country of origin and between behaviour categories: Pearson Product Moment Correlation was used for associations of behaviour categories with popularity. Alpha was set at .05 and was two-tailed throughout.

Results

In summary, just over one-half of the inter-personal interactions comprising the 13 soaps were rated as negative and this proportion increased to two-thirds on exclusion of affiliative interactions predominately rated as positive. The British soaps, in particular the most popular British shows, produced the greatest proportion of negative interactions, while the Australian and least popular soaps furnished the lowest proportion.

Analysis by country revealed that Australian soaps had the lower proportion of negative interactions and British the highest with American intermediate, F(2,4) = 18.0, p < .01. As illustrated in Figure 1, the Australian soaps display a high proportion of negative patterns of hostility relative to positive forms, the American emphasise a high proportion of both negative hostility and power, and the British are proportionately higher on negative hostility, power and fear.

The total disparity between positive interactions and negative (Table 1) was greatest in Australian soaps where positive interactions predominated, intermediate in American programmes where the two were about equal, and least in British-made soaps where negative interactions prevailed. Also presented in Table 1 are the comparable ratios for the three behaviour categories excluding affiliative behaviour that, with only one exception (Coronation Street, shown in Fig. 2) was composed of predominately positive interactions.

By contrasting the most and least popular soaps there is clearly a difference in the proportion of positive and negative forms of the behaviours assessed; the most popular of the 13 programmes showed the greatest number of negative behavioural patterns, while the least popular displayed the fewest (see Fig. 2). In the popular Coronation Street, positive power interactions occur only 43% as frequently as negative types, positive fear only 20% of negative, and positive aggressive behaviour occurs only 10% as often as negative aggressive interactions.

Popularity correlated significantly with the total number of fear interactions observed, r(13) = .61, p < .03, but not with the frequency of hostility, r = .16, affiliation, r = .44, or power, r = .23. Popularity also correlated with the ratio of negative to positive interactions, r = .61, p < .03, and with negative/positive (excluding affiliative) interactions, r = .58, p < .04, over all programmes. Comparable values were found for the correlations for British and for
Table 1: Programme Details

<table>
<thead>
<tr>
<th>Title</th>
<th>Time Broadcast</th>
<th>UK Viewing Figures (millions)</th>
<th>Interactions</th>
<th>Results</th>
<th>Ratio +/-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BRITISH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronation Street</td>
<td>1900</td>
<td>22+</td>
<td>25% (18)</td>
<td>.33</td>
<td>.32</td>
</tr>
<tr>
<td>Eastenders</td>
<td>1900</td>
<td>19+</td>
<td>43% (30)</td>
<td>.75</td>
<td>.43</td>
</tr>
<tr>
<td>Emmerdale Farm</td>
<td>1830</td>
<td>12</td>
<td>43% (27)</td>
<td>.75</td>
<td>.37</td>
</tr>
<tr>
<td>Brookside</td>
<td>1600</td>
<td>7</td>
<td>45% (35)</td>
<td>.82</td>
<td>.54</td>
</tr>
<tr>
<td>Take the High Road</td>
<td>1900</td>
<td>3</td>
<td>42% (32)</td>
<td>.72</td>
<td>.47</td>
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<tr>
<td><strong>Mean</strong></td>
<td></td>
<td></td>
<td>40% (29)</td>
<td>.67</td>
<td>.41</td>
</tr>
<tr>
<td><strong>AMERICAN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falcon Crest</td>
<td>1400</td>
<td>2</td>
<td>52% (56)</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Knots Landing</td>
<td>1410</td>
<td>1</td>
<td>53% (37)</td>
<td>1.2</td>
<td>.59</td>
</tr>
<tr>
<td>Santa Barbara</td>
<td>1000</td>
<td>1-</td>
<td>52% (56)</td>
<td>1.8</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td></td>
<td></td>
<td>50% (41)</td>
<td>1.0</td>
<td>.70</td>
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<tr>
<td><strong>AUSTRALIAN</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighbours</td>
<td>1730</td>
<td>19+</td>
<td>52% (38)</td>
<td>1.1</td>
<td>.61</td>
</tr>
<tr>
<td>The Sullivans</td>
<td>1230</td>
<td>2+</td>
<td>73% (44)</td>
<td>2.0</td>
<td>.79</td>
</tr>
<tr>
<td>Sons &amp; Daughters</td>
<td>1530</td>
<td>2</td>
<td>51% (38)</td>
<td>1.0</td>
<td>.61</td>
</tr>
<tr>
<td>The Young Doctors</td>
<td>1530</td>
<td>1</td>
<td>57% (40)</td>
<td>1.3</td>
<td>.67</td>
</tr>
<tr>
<td>A Country Practice</td>
<td>1400</td>
<td>1-</td>
<td>59% (46)</td>
<td>1.5</td>
<td>.85</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td></td>
<td></td>
<td>56% (42)</td>
<td>1.3</td>
<td>.71</td>
</tr>
<tr>
<td><strong>GRAND MEAN</strong></td>
<td></td>
<td></td>
<td>49% (36)</td>
<td>.95</td>
<td>.55</td>
</tr>
</tbody>
</table>

* Values in brackets are for behaviour patterns excluding affiliative behaviour.

b In England at 1500 hours; bold type indicates prime-time.

c Also shown at 1300 hours.

Australian soaps. The highest correlation with popularity was found between the percentage of negative interactions with affiliation excluded, $r = .68, p < .01$; this association was raised to .78 when calculated for British soaps alone.

The proportions of negative and positive interactions differed between the different behaviours. $F(1,4) = 38.8, p < .0001$. Over all soaps positive fear behaviour was only 80% of negative, positive power was only 62% of negative, and for the behaviour category hostility the proportion was down to 33%. Only for affiliative interactions were positive forms consistently above negative forms: here the frequency of the positive averaged four times that of the negative.

An analysis of neutral patterns, which constitute 11% of the total number of interactions, failed to produce any significant national effect. There was a significant correlation showing that soaps of low popularity had the greatest percentage of interactions rated as neutral, $r = .64, p < .01$. The analysis of direct/indirect communications suggests that overall, slightly more were direct, the contrast being most extreme for fear behaviour. There was no country or popularity effect for this attribute.

FIG. 2. Percent of interactions for the most popular (left—Coronation Street), and least popular (right—Santa Barbara) television soaps.

Discussion

Despite 50% of soap marriages ending in divorce (Cantor & Pingree, 1983), Fishbein (1982) reports that television families were typically portrayed positively. 90% of their interactions being supportive and
cooperative. In our preliminary analysis, just over half the interactions observed on the 13 English-speaking soap operas were those that a family therapist would characterize as unhealthy, undesirable, or unassertive. These negative interactions were proportionately higher in British-made soaps, particularly the popular shows of which 76% of all interactions were negative. Our results suggest that many viewers are likely to have many opportunities to observe ineffective interaction patterns.

The extent to which the characteristics we have described are deliberate choices of soap writers is not published. It is our guess that certain attributes are carefully chosen. The less popular afternoon soaps have women as a target audience, and these programmes portray more positive, more affiliative, and more fear interactions. While it may be that in soaps, suffering is the most powerful vehicle of narrative (Buckingham, 1987), we were surprised that not one character regularly or even predominantly exhibited the types of healthy communications exemplified in family therapy and assertiveness texts. The benefits of such a negative bias may be exciting drama and popularity; we wonder what the costs might be.

Notes

1 The index of concordance called the kappa coefficient was computed using one 10-min sample of each of the 13 programmes and 2 raters. The resulting coefficients are given above for both the positive and negative components (n = 13).

2 These categories, while not used before, are consistent with terminology used by clinical psychologists. Details of definitions of the behaviour patterns are available by request from the senior author.

References


MENTAL AND PHYSICAL ACTIVITY BENEFITS IN ADULTS WITH MENTAL HANDICAP

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Abstract During a 2-hour observation period after 1 hour of mental or physical activity, negative behaviour presented by 11 institutionalised adults with a mental handicap decreased by 24% and positive behaviour increased by 66%. Improvement in behaviour increased over time following mental activity, especially in men. Behavioural improvement was greatest immediately after physical activity and decreasing with time, especially in women. Fatigue can not account for these beneficial effects.

Introduction

The level of physical activity in those living in institutions is known to be well below normal levels. Among children in institutional settings activity levels are over 40% lower than normal (Kielhofner et al., 1983), and in adults the figure is around 50% (Rice, Rosenberg & Radzyminski, 1961). Mental activity is believed to be lower (Lipman & Slater, 1979) but data are not available. Recently there has been interest in using activity to counter abnormal behaviour or abnormal levels of otherwise normal behaviours in impoverished environments (e.g. Bachman & Sluyter, 1988; Chamove, 1986; Flavell, 1973; Kielhofner et al., 1983).

For those living in institutions, providing physical activity leads to reductions of abnormal behaviour by between 21% and 33% in those with mental handicap (Watters & Watters, 1980; Bachman & Faqua, 1983; Bachman & Sluyter, 1988; Duker et al., 1986; Schurrer, Weltman & Brammell, 1985) and by similar amounts in psychiatric patients (25%, Chamove, 1986). That this improvement is biologically based is suggested...
by studies of animals kept in comparably impoverished environments where corresponding reductions in abnormal behaviour occurred after stimulating physical activity (Anderson & Chamove, 1984; Chamove et al., 1982).

Increasing mental activity has also been shown to lead to a three-fold reduction in maladaptive behaviour in elderly people who are institutionalised (Arnetz & Theorell, 1983; Chamove & McInnes, 1989), but the beneficial effect of physical activity is better documented in this population (Stamford et al., 1974). The same is true for institutionalised psychiatric patients where only two studies have looked at mental activity (Chamove, 1986; Boyer et al., 1989). In the first, mental activity led to greater improvement in women than in men and a greater effect on reducing disruptive behaviours rather than increasing affiliative or positive social behaviours; in the second, there were no differences between the effects of mental and physical activities. When using mental activity as a control for physical exercise in normal adults, reductions in hostility and fatigue were found only after physical activity but both types of activity reduced anxiety and depression (Lichtman & Posner, 1983). McPhail & Chamove (1989) reported increases in disruptive behaviour following story telling for adults with a mental handicap at an adult training centre. Using toys leads to an increase in ‘engagement’ in activity from 31% at baseline to 86% of the time (Chamove & McInnes, 1989; Porterfield, Blunden & Blewitt, 1980) and reductions in stereotypies (Berkson & Mason, 1964; Hutt & Hutt, 1965; Flavel, 1973) and self-injurious behaviours (Taylor & Chamove, 1986; Chamove & Anderson, 1981) by up to 85% among institutionalised people with a mental handicap.

Research on the effects of activity in people with a mental handicap has looked only at physical activity. Few studies have assessed changes over time, and all but one (Hussey, Maurer & Schoefield, 1976) have used only pre-adult men. Allen (1980) found a 50% reduction in disruptive behaviour in the first hour after jogging, but as in other studies (Bachman & Faqua, 1983) levels had almost returned to baseline by the second hour. Hussey, Maurer & Schoefield (1976) found inconsistent changes following exercise, namely reductions in attention-seeking behaviour and increases in activity levels.

This study looks at behaviour changes over time following mental and physical activity among institutionalised men and women with a mental handicap.
Method

Subjects

Three men and eight women with moderate mental handicap who were permanent residents of the Royal Scottish National Hospital (RSNH) were selected by nursing staff as regularly engaging in abnormal behaviour and participating in regular organised activities of both a mental and physical nature. They were not matched in anyway or chosen on the basis of any other criteria. Their mental ages ranged from 7 to 11, and they lived on six different wards. People were chosen so that all were ambulant and seizure-free, all engaged in only one of the specified activities daily, and none were given medication that would interfere with their behaviour. As this was a within-subjects design, individual differences were unimportant. Participants were not aware they would attend a particular activity class until immediately prior to leaving the ward.

Consent was obtained from the ward charge nurse for observation of people and ethical approval for the study from RSNH, and Stirling University Psychology Department. The experimenters did not alter the normal activities of the individuals, but observed them for two hours after their normal regime of physical or mental activity in those settings which participants normally used. Unfortunately, it was not possible to have the observer blind to the fact that activities had taken place. Avoidance of bias was achieved by using reliability checks with naive observers and by using salient and clear behaviour categories.

Procedure

One set of baseline observations of all behavioural categories was taken on the ward for 30 minutes immediately prior to the activity. On returning to the ward after the activities, observation began immediately and lasted for a two hour period, subdivided for analysis into four 30 minute periods. One person was observed at a time and records were taken every ten seconds providing 180 observations in every 30 minute observation period. Each subject was observed four times, twice following mental activity and twice following physical activity. Each observation session comprised one 30 minute baseline plus four 30 minute post-activity periods. There were five additional 30 minute baseline observation sessions for each experimental session. The study was doubly-controlled as experimental data were compared both with rates immediately preceding these situations and with base levels at the same time of day on another day without the experimental activity. When the pre-activity baseline was compared with the baseline on
non-activity days, no differences were found so the data were combined for analysis. One experimenter did all the observations (JIB).

Negative behaviour was divided into three categories (from Aman et al., 1985): (1) Abnormal activity level composed of inactivity and social withdrawal, and hyper-activity; (2) Bizarre behaviour composed of annoying behaviour like spitting, stereotypies, and odd mannerisms; (3) Violent behaviour towards self, others, or objects. Positive behaviour consisted of two categories: (1) Affiliative behaviour including initiating positive conversation and positive contact; (2) Positive activity including knitting, reading, etc.

The mental activity took place for one hour sometime between 0930 and 1430 hours in an occupational therapy unit. Mental activity involved tasks of two types, (1) Self-help skills including cooking, bathroom hygiene; and (2) Arts & Crafts such as leatherwork and painting. The physical activity occurred between 1800 and 1900 hours in a large gymnasium, and included engagement in energy-expending activity involving cardiac changes. Physical activities were also of two kinds, (1) Keep-fit including weight-lifting, badminton, and ball games and (2) Disco dancing. Each subject took part in one mental and one physical activity. The activities lasted for approximately one hour, and a subject had to be observed by the experimenter to engage in the activity for a minimum of 75% of its duration for that episode to be included in the data analysis. Other than that, no measurements were made of the vigour or duration of exercise.

Analysis

An analysis of variance (ANOVA) was used to analyse the data; alpha was set at 0.05 and all comparisons were two-tailed. The first ANOVA was a 2 (conditions - mental/physical) \times 2 (behaviour - positive/negative) \times 5 (30-minute time period after activity) \times 2 (sex - male/female), where all but the final factor were repeated measures. Improvement was defined as a decrease in negative and an increase in positive behaviour patterns. Consequently, the values for positive behaviour were altered so that improvement would change scores in the same direction as that for negative behaviour.

Pearson Product Moment Correlation Coefficients were subsequently computed to assess prognostic indicators. These were the four variables listed in Table 1, plus a rating of the condition of the ward from impoverished to enriched, an estimate of fitness level of the subject, and ratings of how much the people enjoyed physical activities and mental activities obtained at the end of all observations. All ratings were on a scale 1 - 10 and were carried out by ward staff.
Results

Over the two-hour period following an hour of mental or physical activity, negative behaviour improved (decreased) by 24% from an average rate of 62%, and positive behaviour improved (increased) by 66% from a baseline rate of 29%. Behavioural improvement increased with time after mental activity, especially for men (Figure 1). Behavioural improvement was greatest immediately after physical activity and decreased with time. (Figure 2). This was especially true of women.

![Graph showing behaviour change](image)

**Figure 1** Behaviour change. Scores for males and females following mental or physical activity.

As illustrated in Figures 1 and 2, the overall ANOVA showed significant interactions of time-since-activity with conditions, $F(4,20) = 4.5, P \leq 0.01$, and time with sex, $F(4,20) = 4.9, P \leq 0.01$, showing that different sexes and different activity conditions produced different trends of behaviour change over time. Both were primarily linear in form, $P \leq 0.007$. There were no significant main effects of sex, behaviour, or condition suggesting that men and women, positive and negative behaviour patterns, and mental and physical activities do not differ in respect of the overall improvement after activity.
Subsequent analysis of the three negative and two positive behaviour categories showed that bizarre behaviour was the category that was most reduced following physical activity, \( F(4,20) = 3.0, P < 0.05 \); the second largest change occurred for positive activity, which also improved after physical activity, \( F(4,20) = 4.1, P < 0.02 \). Mental activity has the greatest effects on affiliative and bizarre behaviour. The only category to show any deterioration was abnormal activity and it was 3% worse in women in the first 30 minutes after physical activity, also showing least overall improvement for men and women combined.

We found significant correlations in four of the eight variables evaluated, indicating that greater improvement was found following activities in those with shorter hospitalisation, from smaller wards, who were younger, and more overweight (see Table 1). These effects support similar findings in the literature (Chamove, 1986; Folkins & Sime, 1981). As clearly shown, correlations with mental activity were significant only when looking at change over the whole two-hour period, whereas behaviour change correlated best with physical activity during the first 30 minutes. Estimates of enjoyment of the activities, ward condition, and fitness level did not influence behavioural improvement.
Table 1 Correlation coefficients between improvement in behaviour during 30-min and 2-hr periods after activity and four variables — age, number in ward, duration in hospital, percent overweight.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mental Activity</th>
<th>Physical Activity</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 min</td>
<td>2-hour</td>
<td>30 min</td>
<td>2-hour</td>
</tr>
<tr>
<td>Age</td>
<td>-0.54</td>
<td>-0.26</td>
<td>-0.64*</td>
<td>-0.15</td>
</tr>
<tr>
<td>Number in Ward</td>
<td>-0.32</td>
<td>-0.20</td>
<td>-0.72*</td>
<td>-0.53</td>
</tr>
<tr>
<td>Duration in Hospital</td>
<td>-0.21</td>
<td>-0.79*</td>
<td>-0.42</td>
<td>-0.37</td>
</tr>
<tr>
<td>Percent Overweight</td>
<td>+0.17</td>
<td>+0.61*</td>
<td>+0.20</td>
<td>+0.48</td>
</tr>
</tbody>
</table>

*P ≤ 0.05

Discussion

We found it surprising and inexplicable that men and mental activity should produce such a different pattern of improvement, increasing with time, in comparison with women and physical activity where the improvement was greatest immediately after the activity. While the gender differences may be due to the small number of men, the gender interaction was statistically significant and therefore must have been large. There have been no previous studies which have directly compared men and women over time, or studies which have directly compared mental and physical activity over time. As men typically show short bursts of vigorous activity and women more consistent activity (Chamove, 1986; Lloyd & Archer, 1976), sociobiological theory might predict men would show more benefit than women from brief vigorous physical activity, and more immediate effects. Our results did not support such a prediction.

As it was not possible to have an observer blind to the experimental treatment of the participants, it is possible that overall behavioural improvement may have been unconsciously exaggerated. However, it is unlikely that the interactions and observed trends would have emerged, indicating the temporal changes, gender differences, and interactions between different activities and different behaviours.

Some of the effects reported here could be accounted for as the result of fatigue. Fatigue could explain the reduction in hyperactivity, reduction in bizarre behaviour, reduction in violent behaviour and an increase in inactivity following physical activity, perhaps because most of these are
active behaviour patterns requiring energy expenditure. Fatigue cannot explain the increases in affiliative behaviour and positive activity following mental and physical activity (although all these require only low levels of energy), and cannot explain why the men showed greater improvement with increasing time after both forms of activity. It is interesting that our hour-long activity should produce effects over a 2-hour period, whereas the 10-min vigorous exercise studied by others (Allen, 1980; Bachman & Faqua, 1983), showed substantially shorter periods of improvement. We also provide evidence that women can benefit as much as men from activities.

It would be interesting to assess the effect of activity periods prior to periods that are typically characterised by high levels of maladaptive or disruptive behaviour (McPhail & Chamove, 1989) and prior to educational classes where improved cognitive behaviour would be welcome.

Acknowledgements

We thank P. Dickens, A.T.C. Feistner, C. McPhail, and those who live and work in the Royal Scottish National Hospital, Larbert who helped in this research.

Notes

1. Correspondence: Dr A.S. Chamove, Massey University Psychology Department, Palmerston North, New Zealand.

References

Mental and Physical Activity


exercise on the psychiatric state of institutionalised geriatric mental patients. 
*Research Quarterly* 45, 34–41.


Enrichment in Primates
Relevance to Occupational Science

It may not be obvious, but the result of research on enrichment in primates is directly relevant to the work of the occupational scientist in general and of the occupational therapist in particular. Some interesting but speculative connections between these arenas have accordingly been selected for discussion. The paper’s primary theme is as follows: While occupational therapists are often concerned with the “work” that incapacitated people would normally be doing, those who provide enrichment to primates are often concerned with the “work” that captive animals would normally be doing. It is my view that “work” is behavior that individuals would prefer to be doing rather than doing nothing or doing what they are restricted to doing by means of their institutionalized or captive conditions.

There have been many studies of environmental enrichment or environmental improvement in primates. In this discussion, primates refers to nonhuman primates below the level of apes, that is, monkeys and prosimians. Although few studies have compared differing techniques of enrichment in animals, two studies that have done so show that, for primates, foraging is the most effective enrichment technique available. These studies compared toys with foraging and found that interest in a single toy is soon lost, whereas foraging maintains its interest over the duration of testing and probably for the life of the animal. The effectiveness of foraging is not surprising when you realize that primates spend between 25% and 90% (usually more than 50%) of their day foraging for food. This involves moving to new food sources, searching for and collecting food at that source, and processing the food. Foraging may accordingly be viewed as the normal “work” for primates.

One way in which the effectiveness of enrichment techniques is normally measured has been to see if subjects perform specific behaviors at all, that is, how
much they like to do it or are motivated to do certain kinds of activities. This technique was used to measure foraging in one species of terrestrial monkeys living in captivity. In their normal housing, the floor was bare and cleaned twice a day. Food was normally fed in hoppers twice a day and was consumed in a few minutes (about 1% of the day). The animals had the rest of the day with nothing much to do, that is, without the work they normally would have to occupy their time in a natural habitat (Fig. 17-1). The monkeys spent about 2% of the day vainly searching the floor for any food scraps that might have been dropped, while aggressive behavior occupied over 30% of their day. However, when clean woodchips were spread over the floor, thereby providing them with opportunity to work, their searching increased to 7% even though there was no food to be found in the woodchip litter (Fig. 17-2). When small items of food (bird seed) were subsequently buried in the litter, foraging time of these monkeys increased to 32% of the day (Fig. 17-3).

It appeared that the monkeys were foraging to obtain the food, yet when they were given free food consisting of containers of bird seed, they still foraged. Recall that they had worked to find food in the clean litter when day after day, there was never food in the woodchips. Moreover, they worked to find food in the litter when the same food was available in convenient buckets nearby. This study suggests that the monkeys enjoyed doing the same type of work that they had evolved to do in the wild when given a chance to work at tasks they normally perform for long periods, so-called “prevalent activities.”

There were other consequences of this opportunity for potentially gainful activity. The most dramatic of these was that squabbling decreased to one third of that present in the bare-floor condition. In other words, aggression decreased when work was available. These findings have been repeated in several species of monkey housed in bare conditions in zoos and laboratories. Making food more difficult to process also reduced aggression.
Figure 17-2. With litter spread in their cage, the monkeys foraged for food. (Photo by Arnold Chamove.)

Figure 17-3. Comparison of percent of aggressive versus foraging behavior in monkeys under differing conditions of potential for normal work behavior.
Although many occupational therapy techniques have not been formally evaluated, it is clinically clear that they are useful. The techniques appear to reduce abnormal behaviors and increase well-being. The level at which they are working is unclear. Long-term psychiatric inpatients appear to improve and report that they feel better on days they exercise. Some theoreticians speculate that participation in exercise leads to increased competence and self-esteem, but primates show the same behavioral effects from activity.

Could it be that the techniques used by the occupational therapist are effective insofar as they increase competence and involve physical exercise or actions? Some techniques may achieve their goals this way, but many effective occupational therapy techniques do not use exercise. Could it be that they are effective insofar as they use occupations that are common in unhospitalized people, normal work?

Few studies are evaluating these questions, that is, assessing the relative effectiveness of techniques based on the component of physical exercise versus prevalent occupations, such as work, similar to foraging in monkeys. The research on primates suggests we can improve their environment and improve behavior by using prevalent activities. Perhaps occupational therapy is tapping a basic biologic predisposition for work when it focuses not just on the physical aspects of activity, but on occupations that have meaning, as do the prevalent activities of our daily routines.

Discussion Questions

1. How valid is Chamove’s basic premise that deeper understandings of human work can accrue from studies of captive nonhuman primates?
2. What are the implications of Chamove’s paper for understanding the experiences of intrinsic motivation, boredom, disease, and health?

References

Appendix 1.
All published work by the author in chronological order.


Appendix Two: Attribution

University of Edinburgh, Regulation 1.1.4: All works submitted must be accompanied by a statement, signed by the candidate: (a) giving full details of any other degree or diploma for which the works, in whole or in part, may have been submitted, and (b) certifying, for each piece of work submitted, *either* that the work is the candidate’s own or, if he/she had been a member of a research group, the precise contribution made by the candidate to each to the works in terms of initiating or leading the research and in the writing up the material.

In compliance with that regulation, I submit the following certificate. I was solely responsible for the initiating, leading, data collection, data analysis, and writing up of collaborative research and research where I am sole author except where I have expressly stated otherwise. Where research is collaborative, I have not repeated the statement that I performed those roles, except when it would be unclear not to do so. Instead, I assert it to be the case that I performed all those roles, except when I have explicitly stated the case to be otherwise. When it was otherwise, I have clearly stated the role played by my collaborators. By default I assert that the remaining roles not specified were exclusively carried out by myself.

NUTRITION

*NUTRITION: Learning*


The phenylketonuria (PKU) programme was begun by Harry Waisman in the laboratory which was run and financed by grants to Harry Harlow. George Kerr joined Waisman, extending the latter’s development of post-natal PKU and low-phenylalanine diets to prenatal PKU. The interest of Kerr and Waisman was in the physiological sequelae of altered amino acid diets, and they controlled the husbandry of the PKU monkeys. Harlow supplied most of the finances and running expenses and suggested the initial battery of three learning tests to see if the monkeys had any mental retardation similar to that found in human PKU. Harlow had developed one of the tasks used (learning-set) and set up the standard battery of tests used to evaluate all monkeys in his laboratory suspected of having some learning deficit (normally with brain lesions). Harry Harlow suggested that these monkeys (like all others) be learning tested on the standard battery of three tests.
(original learning, delayed response, and learning-set). All three were only interested in verifying that the monkey model for PKU also included learning deficits. They were not interested in any more detailed analysis of learning or in any social deficits, possibly as these had not been clearly reported in human PKU. Kerr and Waisman also instigated the development of monkeys fed other high-amino acid diets, low protein diets, and animals with altered thyroid activity. As all the monkeys in these categories were “theirs,” Kerr and Waisman were asked if they wanted their names on all paper in which I tested their monkeys. As I was Harlow’s postgraduate student, I asked him if he wished to have his name on all papers which were written in which I tested any monkey from his laboratory. He made that decision on a paper-by-paper basis. In this paper I did all of, and only the material on learning. I did not initiate the research, but I led the research, and wrote up the material on learning.

   In this paper I did only, and all of the material on learning. I initiated the research, led the research, and wrote up the material on learning.

   John Davenport developed the automated equipment which was used for testing. I did all of the remaining work. Paid workers carried the animals to the equipment for testing. I initiated the research, led the research, and wrote up the material.

   This work is the candidate’s own. As described above, Harry Harlow was the senior scientist and partly (with Harry Waisman) initiated the development of these phenylketonuric monkeys by manipulating their diets. I initiated the research, led the research, and wrote up the material

   As described above, Harry Harlow was the senior scientist and partly (with Harry Waisman and George Kerr) initiated the development of these monkeys. George Kerr made minor comments on the manuscript. The initial testing of these animals was completed before my time, but as the animals were fed at intervals of four hours throughout the day, there was some question of their motivation for food. I initiated their re-testing so that their motivation was no longer in question, and when their food regime was the same as control monkeys. All the rest of the work is my own. Paid testers did the
actual testing of animals and G. Scheffler managed the rearing and maintenance of the animals. I initiated the research and led the research on the re-testing of the animals, and wrote up all the material.


I supervised and designed the learning testing of these monkeys, its analysis, and wrote up that portion of the manuscript. I initiated the research, led the research, and wrote up the material on the learning testing alone.


This work is the candidate's own.


This work is the candidate's own. Theresa Molinaro was employed to assist me in learning testing of monkeys. She was involved to a small extent in discussions about their deficit during the planning stages of this work and in the monkeys' reactions to certain parts of the tasks.


This work is the candidate's own. Paid testers who I supervised did the actual testing of the animals.


This work is the candidate's own. Paid testers who I supervised did the testing of the animals.

**NUTRITION: Social Behaviour**


This work is the candidate's own. Harry Harlow was the senior scientist and together with Harry Waisman initiated the development of these phenylketonuric monkeys by manipulating their diets, as described above.


This work is the candidate's own. One piece of equipment was developed by R. Bowman and another by G. Sackett and R. DeLuna helped record data from the first.

This work is the candidate’s own. G. Scheffler supervised some of the socialisation and R. Sprengel was employed to do some of the testing for me.


This work is the candidate’s own. G. Scheffler supervised some of the socialisation as part of his work.


This work is the candidate’s own, and R. Sprengel helped with the social testing as an employee, and J. Anderson made minor comments on the manuscript.


This work is the candidate’s own. G. Scheffler supervised some of the socialisation, and J. Anderson made minor comments on the manuscript.

**EMOTION: PERSONALITY & DOMINANCE**


Hans Eysenck gave advice about factor analysis and commented on the manuscript; Harry Harlow supported me as a postgraduate student in his laboratory which gave me time to observe those 168 monkeys and develop the behavioural recording system; and R. Sprengel was employed to do some of the testing for me. I initiated the research, led the research, and wrote up the material.


This work is the candidate’s own. Discussions with J. Bauer, another postgraduate helped in the formulation of the categories. This work was submitted by the candidate as part of a PhD dissertation, University of Stirling.


R. Graf worked for Bowman as a technician analysing plasma cortisol and L. Freeman helped me with social testing. I initiated the research, led the research, and wrote up the material.

Bob Bowman ran the laboratory where the cortisol assays were performed, he helped in the design of the study, gave statistical advice, and made comments in the write-up. R. DeLuna was employed by Bowman to analyse the blood plasma and M. Stanek was employed to help me in observation of the animals. I initiated the research, led the research, and wrote up the material.


Dave Saunders was using the Roman Avoidance strain for this PhD, and he did the actual testing of the rats in avoidance learning. He helped in the writing of the manuscript, making a major contribution where the literature of the strain was concerned and in description of the avoidance-learning procedure. The rest of the study was my own. H. Eysenck funded the laboratory and H. Holland supervised its daily running. I initiated the research, led the research, and wrote up most of the material.


This work is the candidate’s own. Years before J. Bauer made the initial comment that if a lighted cigarette was put into a cage of monkeys, the dominant monkey would never touch it first. This work was submitted by the candidate as part of a PhD thesis, University of Stirling.


The initial suggestion for the topic, the hypotheses, and how to test them was mine. Carol Niemeyer suggested the ‘jealousy’ hypothesis, did all the data collection, analysis, and she submitted the work for a masters thesis. I primarily wrote it up for publication. The French summary was written by E.A. Williamson. I initiated the research, led the research, and wrote up the material based on the results she reported in her thesis.


Anna Feistner was a PhD student of W. McGrew’s doing a non-experimental study of food-sharing. When I challenged her saying that monkeys only shared food they did not want themselves, the discussion led to the design of the study. I was substantially involved in the initial planning and the statistical analysis of the data. She was the food-sharing expert and did all the rest, including the study as part of her dissertation. S. Evans taught her to observe details of the animals’ behaviour and B. Smith was employed as an
editor by W. McGrew and made minor changes to the manuscript. I initiated the research, led the research, and jointly wrote up the material with Feistner.


I suggested the topic, the design of the study, re-analysed all the data, and wrote it up for publication. Susan Miller carried out the observations and she submitted the results for an honours thesis. Siân Evans taught her how to observe the monkeys and to identify different behaviour patterns. Siân Evans made substantial comments on the final manuscript. I. Rogerson, F. Moysan, B. Lavery were technicians who maintained the animals; W. McGrew and C. Henty were involved in moving the animals to Stirling. I initiated the research, led the research, and wrote up most of the material.

**HUSBANDRY**


Harry Harlow designed the original Wisconsin General Test Apparatus; John Davenport and myself designed the modification; Davenport had it constructed and wrote up that portion of the manuscript; I did the learning testing and wrote that portion of the manuscript. I initiated the research, led the research, and wrote up the material on learning alone. I was partly responsible but did not initiate or lead the research on development of the apparatus.


This work is the candidate’s own.


I initiated, led, and wrote up the research which was collected from published data. Vicki Nash punched all the raw data onto computer cards; Graham Cameron as an employee of mine wrote the programme which analysed the data.


This work is the candidate’s own. Peter McEwan was instrumental in the physical design of the rooms of the primate unit, and Molly Badham influenced the provision of natural lighting. The idea of the paper came from reading a similar paper by J. MacArthur. V. Nash made comments on the manuscript.

Jim Anderson took the manuscript from draft form to final form. I initiated the research, led the research, and wrote up almost all of the material as an initial draft.


This work is the candidate's own.

**SELF-INJURIOUS BEHAVIOUR**


Harry Harlow suggested to me that I test some mildly self-aggressive monkeys to verify a claim that alcohol reduced self-aggression in humans. He made a substantial contribution to the writing of the final manuscript. I did not initiate the research, but I led the research, and jointly wrote up the material.


Jim Anderson did all the data collection and analysis; the design of the study and the writing of the paper was jointly done; the animals had been reared by me. I initiated the research, jointly led the research, and jointly wrote up the material.


Jim Anderson and I jointly reviewed the self-aggression literature and wrote the review. Jim probably made slightly more of a contribution in both areas than did I. The journal editors asked us to divide the single review article into two. I jointly initiated the research, I jointly led the research, and jointly wrote up the material.


Jim Anderson and I jointly reviewed the literature and wrote the review. Jim probably made slightly more of a contribution in both areas than did I. The journal editors asked us to split the single publish the review article in two parts. As above, I jointly initiated the research, I jointly led the research, and jointly wrote up the material.


Vicky Nash did all the testing which was done on animals she was currently testing for her PhD research. I did most of the rest, helped a bit by Jim Anderson in all aspects except design which was mine. I initiated the research, led the research, and wrote up most of the material.

Vicky Nash did some of the testing which was done on animals she was currently testing for her PhD research. Françoise Bayart did some testing for experience as a visitor to the laboratory. I did most of the rest of the study, helped a bit by Jim Anderson in all aspects including design. I initiated the research, led the research, and wrote up the material.


Study 1 was carried out primarily by Jim Anderson as part of his PhD research; I helped in the planning. Study 4 was carried out primarily by Anderson. Study 2 was jointly planned. Study 3 was conducted by Anderson on animals I had reared. Most of the manuscript was written by Anderson and he did the data analysis for Studies 1, 2, and 4. I neither initiated the research, led the research, nor wrote up the material, but made a substantial contribution in all aspects.


Caroline Taylor collected the data and wrote it up as an honours thesis. The idea was mine, we jointly designed the study, I analysed the data and wrote the manuscript. I initiated the research, led the research, and wrote up the material.

ENRICHMENT


This work is the candidate’s own.


Jim Anderson helped with the literature search and made a minor contribution to the manuscript, primarily polishing the final draft. I initiated the research, led the research, and wrote up the material.


Jim Anderson helped in the writing of this chapter, especially in the final draft, and he contributed the data on the capuchin monkeys. I initiated the research, led the research, and wrote up most of the material.

This work is the candidate's own.


This work is the candidate's own.


This work is the candidate's own.

**ENRICHMENT: Non-social**


Jim Anderson collected all the data, and he made a minor contribution to the final manuscript. I initiated the research, led the research, and wrote up the material


Susan Morgan-Jones did all the biochemical analysis and wrote that section of the manuscript. Susan Jones collected all the data from animals located at Edinburgh Zoo. Jim Anderson collected all the data for animals housed at the Stirling University Psychology Primate Unit. Anderson commented on the final draft. I initiated the research, led the research, and wrote up almost all of the material


Jim Anderson collected about half the data, was involved in the planning of the study, and wrote the first draft of the manuscript. I initiated the research, led half of the research and jointly led the other half, and jointly wrote up the material


This work is the candidate's own. Catriona Thompson provided some of the data on adrenal weights.


Brigit Rohrhuber was solely responsible for that half of the study dealing with cotton-top tamarins whereas I was solely responsible for the other half; I wrote up the final draft of the manuscript.

   This work is the candidate’s own.


   Eleanor Moodie collected all the data, did a preliminary analysis, and she submitted a draft as her honours project. She commented on the final manuscript. I initiated the research, led the research, and wrote up the material.


   Eleanor Moodie collected all the data, did a preliminary analysis, and she submitted a draft as her honours project. She commented on the final manuscript. I initiated the research, led the research, and wrote up the material.

**ENRICHMENT: Social**

**Contact & Attachment**


   Harry Harlow suggested to Gary Mitchell and myself that we do this study, giving rough guidelines as to what we were to do. Mitchell and I collected the data, did the analysis, and wrote up the results jointly and equally. Harlow commented on the manuscript. I did not initiate the research, I jointly led the research, and jointly wrote up the material.


   This work is the candidate’s own.


   The study was initiated, led, and carried out completely by Leonard Rosenblum but left un-analysed. I analysed the data and wrote the manuscript on which Rosenblum and Harlow commented. I neither initiated the research, nor led the research, but wrote up the material.


   This work is the candidate’s own. This work was submitted by the candidate as part of a MA thesis, University of Wisconsin.

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This work is the candidate’s own.


This work is the candidate’s own. Gary Griffin helped in the initial planning stage of the research. This work was submitted by the candidate as part of a PhD dissertation, University of Stirling.


This work is the candidate’s own. This work was submitted by the candidate as part of a PhD dissertation, University of Stirling.


Muriel McLeod MacKenzie collected all the data on animals I had reared under various conditions. Bill McGrew and MacKenzie planned to study kinship, and I suggested adding companionship and rearing. I designed and carried out most of the statistical analysis. MacKenzie and McGrew wrote almost all of the manuscript. MacKenzie submitted the work for her honours project. I initiated part of the research, did not lead the research, and wrote up only parts of the material, especially those parts involving statistical results.


Jim Anderson did all the testing, analysis, and wrote the manuscript. He tested those animals that he used for his dissertation, the mirror group, as well as those animals I had used for mine, all other groups. He used a slide and film sequence that I had developed. I initiated only a small part of the research, did not lead the research, and did not write up the material, although commented on the final manuscript.


Geoff Hosey completely did study 4 and sent me a draft, Peter Schätzel did the section on mandrills, study 3, which I subsequently rewrote for publication. I did the remainder.
I initiated and led the research on two parts out of the four, but wrote up all of the material for study 3 from a German draft and some of the material for study 4.

**Vision**


This work is the candidate’s own.


This work is the candidate’s own. This work was submitted by the candidate as part of a PhD dissertation, University of Stirling and supported by a grant from the Medical Research Council.


Susan McKenzie with help from Anna Feistner collected all the data and McKenzie submitted a draft as an honours project. Feistner taught McKenzie how to recognise different behaviour patterns. McKenzie and Feistner made comments on the final manuscript, Feistner making substantial grammatical improvements. I initiated the research, led the research, and wrote up the material.


The data collection was done by Bradley Grimmer on bulls on his farm. He submitted preliminary results as a class project. I initiated the research, led the research, and wrote up the material.


Craig Whittington collected all the data, did the data analysis with minor help from me, and wrote the first draft of the final manuscript. I initiated the research, led the research, and jointly wrote up the material.

**Activity in Humans**


This work is the candidate’s own. The work was based on the results of a thesis submitted by the candidate in partial fulfilment of the degree of MPhil, University of Edinburgh. I initiated the research, led the research, and wrote up the material.

This work is the candidate’s own and was based on the results of a thesis submitted by the candidate for the degree of MPhil, University of Edinburgh.


This work is the candidate’s own. The work was part of the literature review for a thesis submitted by the candidate for the degree of MPhil, University of Edinburgh.


This work is the candidate’s own. The work was part of the literature review submitted by the candidate for the degree of MPhil, University of Edinburgh.


Janet Brown collected the data, did a preliminary analysis, and she submitted her work as an honours project. I initiated the research, led the research, and wrote up the material.


Catherine McPhail collaborated in the design of the study, collected all the data, did the analysis, and wrote it up as an honours project. She made a substantial contribution to the final manuscript. I initiated the research, led the research, and jointly wrote up the material.


Muriel Young was the health visitor who compiled all the data which I extracted and then used. I initiated the research to use existing data, led the research, and wrote up the material.


Kimberly McInnes collected the data and wrote results for an honours project. She commented on the final manuscript. I initiated the research, led the research, and wrote up the material.


Muriel McLeod McKenzie collected together all the data from clinical notes and prepared it for computer analysis. The treatment cases were those of Bill Jerrom and Kevin Power.
All three made comments on the final manuscript. I initiated the research to be based upon existing case notes, led the research, and wrote up the material


Valerie Wood reviewed the literature, collected the data, and presented it as an honours project. The literature review is totally her work. She made comments on the final manuscript. I initiated the research, led the research, and primarily wrote up the material based upon her literature review and on her project.


Paula Mullins collected the data and did a preliminary analysis which she submitted as an honours project. The literature review and the methods are largely her work. I initiated the research, led the research, and wrote up the material based on her project.


This work is the candidate’s own.


This work is the candidate’s own.

**In summary.** of the total of 81 articles submitted by the candidate for the degree of DSc, 35 (43%) are the candidate’s own work, and a further 22 (27%) the candidate initiated, led, and wrote up the material. For the remainder, excepting for numbers 50 and 58, the candidate either initiated, led, and/or wrote up all or a part of the material and made a substantial and essential contribution to the research. Eleven of the 81 articles are works which, in whole or in part, have been submitted for another degree or diploma by the candidate.