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A Thesis

on

Associated Movements in Hemiplegia,

by

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for

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(under Old Regulations)
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Introductory

Hemiplegia, one of the commonest conditions encountered by the general practitioner in the course of his daily rounds, has been a subject discussed by multitudes of writers from earliest times. At first sight it seems a subject altogether beyond the scope of one who is not a trained neurologist or brain specialist, in these days of advanced microscropy and minute anatomy. That this is true of the disease in its entirety must be admitted. At the same time it has been considered profitable here to undertake the examination of one at least of the symptoms with the hope that an earnest and close study of this minute section may be of some permanent value.

The comparatively recently in the history of medical advancement authors have been content to note that associated movements do occur in hemiplegia, and to describe cases in which they have been observed. As to their significance, clinical or otherwise, or their causation, little information was forthcoming till Broadbent in the year 1864 first advanced a reasonable hypothesis.

Even quite modern textbooks may be searched in vain for any full account.

A recent stay of some months in London has enabled the author to study the subject at the National Hosp for Nervous Diseases, Queen's Square.
The wealth of material there met with and
the insight derived from the able teaching
invariable kindness of Sir Wi Towers under
whom he worked rendered the task more
profitable than had it been undertaken
whilst in private practice.
Part I

Definition of 'Associated Movements'.

Division of the Skeletal Muscles into Three Great Classes. Comparison of the frequency with which Associated Movements are to be observed in these Classes.

Generally speaking, the result of what is popularly termed a 'stroke' is a paralysis of certain parts of the body on one side, i.e. a hemiplegia. It may be only a slight weakness or ticsus confined to one group of muscles, or it may be a complete paralysis of one side of the body. Whatever the degree, the sufferer has lost a certain amount of voluntary control over the affected muscles. His Will can no longer produce exactly the movements it was formerly able to bring out.

From all times, moreover, it has been noted that certain movements are apt to occur in these paralysed muscles, which are not 'Will' movements, in association with movements that are 'Will', and also in response to certain reflex acts such as yawning, sneezing, 
certain writers by the term 'Associated Movements' imply only the former & exclude the latter, giving rise to some confusion in consequence. It is here considered right to accord the wider significance and to offer the following simple definition: - Associated Movements are involuntary contractions of paralysed or partially paralysed muscles occurring...
in connection with voluntary contractions
of healthy muscles or in response to reflex
stimulation.

It is difficult to formulate a satisfactory de-
scription or definition. The above may be said
to exclude involuntary contractions on the un-
paralysed side in response to movement or
stimulation if the partially paralysed muscles
on the other side. That these do occur is
well known, but we prefer to maintain the
above definition for the sake of clearness &
brevity.

A classification of the muscles of the human
frame may be made by dividing them ac-
cording to their action on the two sides of
the body & the influence on them of the
"Will", as follows:—

I. Muscles which act bilaterally, syn-
chronously & automatically, over the action
of which the "Will" has a certain control,
though it has no power to make them act
unilaterally. e.g. thoracic muscles, abomi-
nal muscles, muscles of the upper face.

II. Muscles whose habitual action is bi-
lateral but over whom the "Will" has suf-
ficient power to cause unilateral action
when required. e.g. eye-lids, lower facial
muscles, etc.

III. Muscles whose habitual action is unilater-
al & which are entirely dependent on the
"Will". e.g. fingers, toes, etc.
Certain individuals can produce unilateral action in muscles usually acting bilaterally. They can raise one eye-lid, move one ear, but these are so seldom met with that for present purposes they may be neglected.

My first task is to examine briefly hemiplegia as it affects these three classes:

I Effect of hemiplegia on those muscles which have purely bilateral action:

A short examination of a series of cases easily demonstrates that paralysis here is rare and usually temporary. The hemiplegic breaths up to par. The intracranial and abdominal muscles contract or expand rhythmically and with equal force on the two sides of the body. The head is turned to either side, forward or backward, with unimpaired ease. The eye lid moves with normal regularity and equality. Only in a small proportion of cases, or in cases seen early, do we find evidence at all marked, and even there it is necessary to call out "forced" movements before it is satisfactory. The ptosis may then be made to stand out more clearly on the non-paralysed side (Case V). Movements requiring additional voluntary effort, such as raising the body into the sitting posture also bring out discrepancy.

A hand placed on either side of the abdominal automatisms can detect a difference in the strength of the muscular contraction on either side. I sometimes also a delayed action of the weaker muscles.

II Effect of Hemiplegia on those Muscles whose
accustomed Action is bilateral but over whom the Will has sufficient power to bring forth Unilateral Action.

In this class paralysis is more marked than in class I. The proportion of cases in which it is met with is much larger, and the severity of the paralysis greater. Take as an example the upper eye-lids. In the normal being the Will has the power to close either lid sufficiently. But the hemiplegic patient though working equally on the two sides, has not the same power of unilateral action. He can still close the lid on the un-paralysed side without calling the neighbouring lid into similar action, but he is quite unable to bring forth unilateral action on the affected side. Similarly in producing "forced" movements, telling the patient to "screw up the eye fixed," the resistance offered to forcing opening of the lids is markedly less on the side of the hemiplegia. The lower facial muscles, which act unilaterally or bilaterally, are usually markedly paralysed. Even with the face at rest, the flattening of wrinkles & the appearance of immobility reveal the mischief even in a very slight case. To give another example, "shrugging" the shoulders. An action which is bilateral but may be made unilateral at Will. Here the paralysis is extremely common.

III. Effect of Hemiplegia on Muscles whose usual Action is Unilateral.

Practically there are invariably paralysed, but usually merely. I usually none of this paralysis
persists. This class includes the movements of fingers and toes, the movements of the arm and leg.

The variety of these movements is infinite. The fingers alone are capable of such delicate unilateral action that their almost invariable paralysis would alone suggest the greater effect of hemiplegia on these muscles with unilateral action.

Having thus briefly passed over the facts of hemiplegia in these various movements, it is only necessary here to point out that just as the proportion of paralysis is greater as we pass from Class I to classes II and III, so when we come to examine the Associated Movements occurring in the muscles of these classes, it will be found that in the same way they are most frequently observed in proportion as the will has the wider action. To try and actually classify Associated Movements as they are met with in these classes is as unnecessary as it is impossible. The fact that paralysis of muscles in Class I is so seldom met with, makes the search for associated movements in these muscles, when they are slightly affected, a matter of no easy performance. Indeed the question that at once arises is, are not all these movements of bilaterally acting muscles, which also occur on the side that ought to be paralyzed not in the nature of 'associated movements'?
Part II

Associated Movements.

Section I. Their Varieties

II. Their occurrence in thirty unslected cases.

Section I Varieties.

From the examination of a large number of cases, thirty of which are treated of later, it becomes possible to classify associated movements as follows:

A. Involuntary movements initiated in the paralyzed side of the body by voluntary movements, active or passive, of the non-paralyzed side.

B. Involuntary movements initiated in the non-paralyzed side by voluntary movements, or attempted movements, of the paralyzed side.

C. Involuntary movements of paralyzed or partially paralyzed muscles initiated by involuntary reflex spasms such as sneezing or coughing.

D. Movements induced by peripheral stimuli, e.g. a pinch, dressing a painful wound, etc.

A.

Under this heading we find probably the
largest number of movements; or, to put it
out
more clearly, of the cases of hemiplegia in which
the greater portion of them have movements
belonging to this class. In testing the cases
I am about to cite I followed as far as
possible a regular routine. In the first place
the patient was requested to show all the
movements possible in the affected limb or
face. Next he was told to clench the stronger
hand firmly, and the paralysed one was
watched for involuntary motion. Clenching the
paralysed hand, directing the whole attention
strength in the effort, followed, & the unaffected
hand watched. The paralysed hand was then
held & the patient told to "squeeze your hardest,"
or the force of any, noted. Then both hands
were seized & again the same order given. Any
difference in the strength of the movements of
the paralysed hand again noted. As far as
possible, a similar procedure was adopted in
the case of the lower extremities, though in
cause no 'grasp' is here possible; employment
of tests against resistance on the part of the
observes was here more usual.

Out of thirty cases examined for movements
of this variety distinct evidence was forthcoming of their presence in nineteen. In some
they were slight. In many there was no appreci-
able accession of strength to the grasp of the
paralysed, or paralysed, hand on the patient being
directed to grasp also with the non-paralysed hand, but all betrayed some movement when the patient was directed to the performances of the healthy limb. In some the associated movements were only to be seen on making the patient move the sound limb against strong resistance, e.g., endeavouring to hold the unparalysed leg stationary whilst the patient did his best to move it. Frequently when the latter test was employed the paralysed limb moved in the direction the patient was endeavouring to move the one held down.

These movements in the paralysed limbs are not to be found only in the cases where rigidity is most present. The contrary, almost, seems the case. Out of the 12 cases which I have recorded at length, one had developed spasticity in every one of them there was associated movement with the exception of the last.

When we examine the paired muscles for associated movement with regard to their paired action we find the evidence of this existence far from strong. There is usually no paralysis of these muscles over whose paired action the will has no ensuing action. Any which is slight is soon followed by the right or left side of the chest and abdomen are to all appearance normal, I think is, of course, no possibility of producing movements unless class A where unilateral action does not normally exist. The same applies to the upper face & the neck & back muscles which the will can not throw
into one side contraction.

B. The movements are first occurring on the sound side or work being done by the muscles of the paralyzed side are very similar in character to the converse movements already described. They are not so frequently met with but there is little difference in this respect. Again for the reasons above recorded, one does not find associated movements in muscles of Class I. Class II exhibits a certain proportion, but the larger number are restricted to the muscles over which the Will has fullest authority.

C. Associated movements in response to and reflex muscular "earthquakes" is surprising. Yawning & coughing are also extremely common. Their variety is very great & they are to be observed in completely paired, semi-paired, or independently acting muscles. The commonest are seen during coughing. Some hemiplegics have movements at every cough. In one of my patients, a young woman with early phthisis this was so (Case IV). She had an incessant cough. At each cough the forearm on the paralyzed side was slightly raised from the bed, the wrist & fingers similarly, but much more markedly called into action, yet the non-paralyzed hand never moved. Sometimes cases are met with, however, in which movements of the latter as well as the former. A good sneeze produces the same result. Looking to this fact, in some cases we find that any violence noticeable of paralysis in the superior half passes away at a cough.
In many of the cases recorded, a cough produced a diminution in the facial distorsion. Though the Will had not the authority to produce the same result. More commonly, however, it is the reverse. Coughing & sneezing simply aggravate the disfigurement. Still less frequently do we find movements in the lower limits on such acts being included. On rare occasions only does a cough produce any visible alteration in the position of either left or right eye.

As regards the curious anomalous observation that sneezing or smiling or coughing sometimes accentuate & at others diminish the distortion I have discovered in or in two cases recorded that there is a distinct difference in the result if the act be differently brought about. I may be understood if I put it in this way, an artificial smile, i.e., a smile to order, manufactured by the patient willing a movement on each side, increases the distortion; a smile induced quite unexpectedly by means of some happy remark, one taking place without the intervention of the Will, frequently diminishes or abolishes the distortion, that is, produces associated movement in the paralyzed muscles.

I have made myself certain of this in at least one of my cases, having produced the two different "smiles" in the patient & compared the results (Case III).

Again, for associated movement on coughing, a good test muscle is the Latissimus dorsi. Thii
was well pointed out by Dr. Chas. E. Bewor (1) whose attention was drawn to the fact during a search for a muscle in the body which would act unilaterally in one class of movements, bilaterally in another. Whilst examining patients he observed that when coughing a latissimus dorsi muscle, whose unilateral action in the upper extremity was paralysed, contracted with vigour bilaterally. The point to make the test is found in the prominent fold of the muscle crossing the axilla. By holding this fold between finger and thumb & causing the patient to cough the contraction of the fibres is well felt. Dr. Bewor was surprised on finding further that a contraction was also felt on inspiring deeply, though of a very much slighter order. One and the same muscle contracting during both respiratory & inspiratory efforts. He summarises his results of the examination of a series of cases as follows:

1. On reflex coughing the expiratory action of the latissimus dorsi was about equal on the two sides.

2. On voluntary coughing the action of the latissimus dorsi was obtained on the paralysed side but was frequently diminished in action, or occurred later than on the normal side.

3. In all cases the unilateral and voluntary action of adducting the shoulder was absent.

This test was applied to each of my cases & I found that Dr. Bewor's results tallied closely with my own.
A similar test though hardly a parallel one is suggested in the work of M. Blanchard (2), also by A. Sicard (3). These writers lay stress on the possibility of discovering unilateral weakness in the abdominal muscles of the male by placing a finger over each internal inguinal ring and asking the patient to cough. They maintain that a delayed action on one side is to be detected if a greater impulse given to the fingers on the same side. These authors do not enter, however, into a comparison of the effects of a voluntary endeavor to sit up and an involuntary cough. From my own cases I do not find it possible to express an opinion on this point. In no case could I satisfy myself of any difference in the impulses conveyed to the examining fingers. Yet in at least one case we find a difference recorded in the action of the recti on attempting to sit up (Case I).

D.

Reflex movements appearing in response to peripheral stimulation:

These movements are different in nature to those already described and appear most frequently in response to percussion. Many writers on the subject of associated movements refer to them.

Nottmaged (4), who believed that except during the period immediately after the attack there occur very few cases of hemiplegia which do not present some associated movements, describes them in some detail. He points out the remarkable
dissimilarity in the amount of response to apparently similar stimuli in different cases. He says that (i) The fullest excitations sometimes call out energetic contractions in immovable limbs. (ii) The strongest excitation may produce no movements whatsoever. (iii) The excitation at certain parts may bring forth movements in quite distant parts.

With regard to the latter he quotes a case recorded by Marshall Hall, where the dressing of a severe wound alongside of the humerus vertebra, produced a powerful contraction of the right arm.

(iv) That in certain cases jerking the paralysed limb causes contraction in the non-paralysed limb, if a severe jerk be given that not only the corresponding limb moves but also the other limb, upper or lower extremity, as it may be.

Bastian (5) supports these statements and refers to Bichat & Bichat. The former as asserting that in certain rare cases clonus produced on the one side may also be on the paralyzed side and followed by clonus on the sound side. The latter as being responsible for the statement that jerking of the patellar tendon on the paralyzed side produces not only a contraction on the side struck, but also on the healthy side; also that a careful study of the deep reflexes on the sound side in hemiplegia reveals the fact
that they are really never healthy. Bastian himself (6) describes a case of this sort.

Halloran (7) a similar, and two are recorded by Armerol (8) which were remarkable in being unaccompanied with rigidity.

Blanchard (9) describes a reflex movement obtained in the adductor muscles of the thigh on percussing the patellar tendon on the healthy side while the lower extremities are in a certain position. The patient is placed in the dorsal decubitus in order to elicit this phenomenon. The knees are drawn up and widely separated while the heels are kept together. Indirect percussion is then performed. The knees may even approach the middle line. Blanchard refers also to the Babinski reflex and the 'Schaffer'.

The former consists in an extensor response to stroking the sole of the foot or the paralyzed side; the extensor occurring mainly in the great toe. The latter appears on tapping smartly the calf of the tendo Achilles. In a healthy subject one obtains flexion of the great toe & foot, in a hemiplegic subject extension.

These various movements were all sought for in the cases I have examined and, in certain of them, were obtained as will be seen on going over the history of each one.

Though not so common as the movements observed associated with voluntary movements
on either side, still they were found in a certain proportion. Cases III., IV. & V. may be specially cited out of the twelve cases recorded at length. Of the eighteen cases observed casually in the outpatients at Queen's Square no less than seven showed various degrees of "spread" to the affected side on calling forth the plantar reflex of one extremity. In four of these seven contractures appeared on both sides only on percussing the tendon on the sound side, in two only on tapping the tendon on the affected side. In one there was a trace of response in the paralysed upper extremity on eliciting the "triceps reflex" in the reflex on the sound side.

The plantar reflex giving external response was found to be very common in patients observed in the Wards of the Hospital, where there was paralysis of a lower extremity, in fact almost invariably with the exception of comparatively recent cases. Especially was this so in cases where the deep reflexes on the paralysed side were markedly increased whilst those on the healthy side were not, and where there was no great amount of rigidity.

The nature of these various Associated Movements will be further appreciated by the study of the following Cases, which in two exceptions were taken in the Wards at Queen's Square, Bloomsbury.
Cases.

In all, thirty cases were carefully examined. In the main part they consist of patients attacked for the first time, though a certain number had suffered several strokes. Twelve are recorded very fully, the greater part having been in-patients at Queen's Square, Bloomsbury, W.C. Two occurred in private practice. Eighteen were casual out-patients picked at random.

Case I

E.S. A frail, grey-haired man, aged 68.

Complaint.—Paralysis of right arm.

Past History.—3 months previous to present illness had a severe fright. Assaulted, but not injured, in the street. Health had always been good. No previous habits. Never had syphilis.

Family History.—No facts of importance.

Present Illness.—Suddenly woke up in the morning and discovered he had lost all power in his right arm, & that his face was thick. Gradual but daily improvement. Speech almost recovered on admission to Queen's Sq. National Hosps. 3 weeks from the date of the attack.

Present State.—A slighty built man with concomitantly troubles temporal arteries. Facial paralysis of the right arm. Only slight voluntary movement at shoulder & elbow joints. Cannot move the fingers. No true of facial paralysis cranial nerves normal. Optic disc normal. Heart and
Lungs normal.

Albuminuria - very slight.

Emaciation - present in paralyzed member.

Spasticity - none.

Deep Reflexes: Those of the paralyzed arm, biiceps and triceps, are markedly exaggerated. Of the left arm, not exaggerated. Right knee jerk slightly more brisk than the left. Achilles jerk also a degree sharper on the right side.

Deep Reflexes: Diminished. Plantar, flexor on the left side, plantar flexion on the right.

Associated Movements.

Parotid muscles normal. During breathing the muscular action, thoracic and abdominal, is equal on the two sides. Patient can from, raise the eye brows & oppose the teeth equally well on the two sides. Can close either eye separately at will.

No paralysis demonstrable in face, trunk, penis, or leg. On coughing, sneezing or yawning no movements are observed occurring involuntarily in either the paralyzed or unaffected limb.

On voluntary movement of the latter no associated movement is seen in the palsied limb till the patient is ordered to put forth his strength. The grasp of the right hand is practically nil, but is slightly more evident when patient grasps as powerfully as possible with both hands. This is the only 'associated' movement in the palsied limb. The ability to raise or swing the right shoulder is much reduced. The flexion of the carpo-macromuscle in the wrist contracts on coughing though not on unilateral action on the arm.
Case III


Complaint. Paralysis of right arm and leg.

Previous History. Has ever been a healthy man.

Accustomed to liberal diet and light work.

Denies syphilis and alcoholism.

Family History. No facts of importance.

Present Illness. - Onset was gradual with real loss of consciousness. Fell faint while crossing a field.

Then a numbness and twitching of the type of the fingers of the right hand. In two or three minutes a weakness in the right leg. His companion supported him at first, but in a short time had to procure assistance and carry him.

Proximately left the right arm and leg & the speech became affected. Was told his face was twisted.

Present State. - Taken 12 weeks later in the National Hospital. - Patient is stout & hearty.

Speaks well, can sit up but cannot walk.

Palsy of the right arm and leg. Patient states that the leg improved much in the month previous to admission, the arm to a less extent. Heart and lungs normal. Cranial nerves normal. Face - sphincters normal.

Albuminuria - none found.

Erythrasma - none

Spasticity - none

Reflexes - not exaggerated on either side. Plants is flaccid on both sides.

Associated Movements - In the lower extremity,
there is very slight movement if the affected limb is voluntarily moved against resistance. This occurs both in the parasitic limbs when the unparalyzed limb is moved & vice versa. Similar phenomena on raising the limbs from the bed. The hand group of the affected side is not appreciably greater when the normal one is clenched tightly. Yawning, coughing, sneezing, etc. produce no involuntary movements on the parasitic side of the body, slight on the other. There is no action of reflex nature on both sides when the patellar tendon is stricken. Latisimus dorsi test shows stronger bilateral than unilateral action. The difference, however, is not great. Patient has power to swing the shoulder though the weakness is evident when compared with the other side. Similar weakness is betrayed by the fibres of the Latissimus dorsi when they are tested with action.

Case III

H. A. A woman of 42, looking 50.
Complaint - Paralysis of left face, arm and leg.
Previous History - Four attacks of rheumatic fever, in one of which she was told her heart was affected. Always was a hard-working woman when able on account of her heart. Since years previous to admission she had her first stroke. Present illness is her second. In the former she was unconscious.
for seven hours & was then paralysed on the right side, face and limbs. Gradual and complete recovery. Face first, then arm & lastly the leg. In three months her recovery was accomplished. During the two years preceding her present illness she has had a cough and has got blood occasionally.

**Family History** - No facts of importance.

**Present Condition** - On admission to the National Hospital for Neurosis Diseases, two weeks from the commencement of her illness.

A melancholic looking, pale woman. Erythelial. Frequently weeps. Gray hair. Specks in mouth. Unable to walk. Paralysis of left face arm and trunk leg. Has very slight voluntary movement at the shoulder and elbow, none of the hand or fingers. Can move the paralysed leg in a weak fashion.

Voluntary movement of muscles of left face very defective. Lungs normal.

**Heart** - Apex beat displaced outwards an inch at least. Very irregular impulse. There are two murmurs at the apex, presystolic and diastolic. They are difficult to make out unless the patient first be made to do what movements she can in the way of exercise. There is a distinct thrill.

**Cranial nerves** - Paralysis of nerve supplying muscles of lower face on left side.

**Albuminuria** - none

Emaciation - present on paralysed side.
Spasticity. Present. More marked in the arm than the leg.

Reflexes. Plantar on left side is extensor, on right plantar. The deep reflexes are all very brisk & exaggerated, but more especially on the left side.

Associated Movements.

Face. Independent power of closing left eye lost. Cannot resist observer forcing the closed lid open on that side so well as on the right.

Voluntary movements of the facial muscles are poor on the left side & are quite as poor on patient manufacturing a cough or smile, but on two occasions in response to an unpremeditated 'laugh' there were visible distinct associated movements of that side.

Throat. Muscles acting bilaterally are but slightly affected. Intercostals & abdominals act equally on the two sides except on forced respiration. Shrugging poor on paralysed side.

Fed of Larynx. Vocal cords move fully on its bilateral action being called out as in a sneeze, than in its unilateral action on the arm. When patient endeavours to sit up, the contraction of the abdominal muscles on the left side is less energetic than that of those on the right side.

Extremities. Associated movements occur in the paralysed upper extremity on exerting the other. They are called out mostly when the exciting movements are very powerful.
Patient grasps in weak on both sides, more so in the right than was to be expected. Converting |
in a knee-jerk, or plantar, produced only sometimes a slight flail-like movement of the |
left forearm. Percussion of the patellar tendon on the sound side brings out a contractil |
response from both legs. Adductors reflex contraction is marked. Patients knees |
being drawn up, heels put together and |
thighs separated. Patellar tendon on healthy |
side being tapped a contraction occurs of the |
adductors on the paralyzed side, approximating |
the legs, knees slightly. |

Case IV |

Mrs. J. D., Age 26. |
Complaints — Weakness of right arm and leg. |
Obstructive cough, loss of flesh. |

Present History — Occasional rheumatic pains. |
Pains of left side 6 years ago. Otherwise a healthy woman till onset of present |
illness three years ago. |

Family History — Father died at 45 from chest |
tuberculosis. Patient calls it chronic bronchitis. |

Present Illness — Sudden onset three years ago |
while walking out in perfect health. Stumbled |
and fell. Soon found complete loss of power |
in the right arm & slight loss in the right |
leg. No loss of consciousness. Managed to |
stumble home. His face was twisted and
Speech confused. During the next two days, the right leg became completely paralysed, & she became unable to sit up in bed. In late five weeks, she was sent into hospital, the lower extremity by this time was stronger, the face practically well, but the arm very weak. Remained in hospital some months with slow improvement. Since then his general health improved until recently when she commenced to cough.


Albuminuria - Trace present.

Emaciation - General, but especially noticeable in the paralyzed extremities.

Spasticity - Marked. The right arm is specially affected. The elbow is bent, the hand flexed and adducted. Fingers closing in on the palm but easily straightened.

Reflexes - Plantar is extension on right side, flexion on left. All the deep reflexes are
trigeminal, especially those on the right side. Though clonus present on right side, suspicious on left.

Associated Movements.

Sufficient associated movements occur in the face during laughing, etc. to remove all trace of the old paralysis. In the extremities there are marked phenomena. All movements performed against powerful resistance, by the non-paralysed side cause movements in a similar direction by the paralysed. For instance, the movements appear in the normal limits on using the paralysed one or attempting to do so. In the lower extremities the result is the same. The movements even more marked.

Coughing always produces movements in the paralysed arm. These are of slower character & affect the fore-arm. The movement observed is greater than patients can voluntarily bring forth. They occur at every cough & patient maintains they have been coming on for 18 months. The grasp of the paralysed hand, if grasp it can be called, is more feeble & whilst patient is exerting the other hand to its strongest 'squeeze'.

There is very marked difference in the strength of contraction of the fold of the latissimus dorsi during bilateral action and unilateral. Reflex associated movements are brought out by percussion of the patellar tendon on either side. Both legs 'jerk' at the knee.
Similarly, if the patient's legs be placed in the position necessary, contraction of the adductor of the thigh is demonstrable. The knees are visibly approximated.

Case V


Complaint: Paralysis of right side of the body.

Imperfect speech.

Previous health: Never had lead poisoning. Occasional goutiness. Always of moderate habits as to food and drink. (Syphilis?)

Family History: One brother died of Puerperal disease. Patient has 2 healthy children. His wife has had no miscarriages.

Present illness: Sudden onset 5 weeks before admission. No headache or other warning. Found he could not button his coat in the morning nor was he able to ask his wife to do it. Wife states his face was not drawn but he was very pale. He was put to bed and paralysis became complete of right arm and leg, with loss of consciousness.

P. C.: A man of average build and development.

Understands what is said to him or written.

Utters some words artlessly, mostly Phonic in common use and with recurring utterance. "Yes, yes", "No, no", always in the proper sense. Cranial Nerves: vision very defective on left side.

Both ears show marked cerebral degeneration.
and the right has a flame-shaped haemorrhage to its inner side. Tongue deviates to the right.

There are no sensory abnormalities.

Heart and lungs—normal.

Mitrudium—none found.

Emaciation—marked on the affected side.

Spasticity—none or slight.

Reflexes—Increased, at least on one uninjured side.

Plantar reflex is extensor on the right side, flexor on the left.

The muscular system is poor. There is a flaccid right-sided paralysis.

Associated movements—

There seems to be no appreciable difference in muscle accustomed to act in concert.

But when in the patient, in a patient facing his head forwards against resistance, it stands out distinctly on the left side. Intercostal and abdominal muscles act equally and when moving automatically, coughing, sneezing, etc., but less strongly on forced inspiration and employment of voluntary effort.

Muscles from trunk to paralysed limb are much affected as regards their unilateral action, but on coughing the edge of the iliococcygeus muscle stands becomes quite firm for a second. On trying to raise himself up in bed, the healthy leg rises. On voluntary movements of the right limbs there are traces of associated movements, similar in character, on the paralysed side.
A month later—Condition little altered. The patient cannot now be caused to stand up as formerly. Associated movements in one side in response to voluntary movement on the other are very slight. None in the limbs on patient coughing. No response on percussion of one patellar tendon, in the other leg.

Case 61

J. H. H., age 52.

Complaint—Weakness of arms and legs on both sides, especially the right.

Previous History—'Sore-throat' in 1899. Was exposed to veneral infection. Swollen testicle three months ago.

Family History—Father died of heart disease. Paternal aunt of hemiplegia. One of patients children died young, cause unknown.

Present Illness—Commenced ten months ago.

For some days he had felt a numbness and tingling in the right hand. The attack came without warning. No loss of consciousness or convulsions. Speech at first was unintelligible but rapidly improved in the next few days. There was no twisting of the face. In a few days he was removed to hospital where he remained six weeks. He could then walk with difficulty. A month later, when both arm and leg seemed to be improving, patient suddenly collapsed as he was walking across
a room. This time his right leg alone was affected. The arm continued to improve as time went on, but the leg remained much as it was. Three months later, a weakness appeared in the left arm & later, in the left leg. To this was added incontinence of urine.

Present Condition - A large, robust man with acne spots on his face (probably from taking isotride).

Cranial Nerves - Defective lateral movements of both eyes and some nystagmoid jinkings. Diplopia, also objects double when held to either side and below the horizontal level of his eyes. The images are uncrossed, parallel and at the same level. 3rd nerve - Right masseter weak. 4th Right naso-labial fold less marked than the left. 12th Tongue protrudes straight but its movements are spastic.

Muscular System - There is slight general weakness with weakness of all muscles. The intrinsics muscles on the right side are especially poor. Lateral movement of head to right is weaker than to left.

Lungs - normal

Heart - Accentuation of 1st mitral and 2nd aortic sounds. No murmur.

Albuminuria - in trace

Emaciation - present

Spasticity - present

Reflexes - All are brisk, on both sides of
the body, but there is a distinct difference, the
right side of the body exhibiting the broken
jerk. Weakness close at both ankles. Close
at right wrist:

Associated Movements.
Parietal muscles are all acting equally. In e-
veloping voluntarily, as in deep respiration, the
left side of the chest acts more vigorously than
the right. A similar difference is noticeable
in the abdominal muscles on patients attempt-
ing to sit up in bed. Special attention was
paid in this case to the rise of the diaphragm to
the rigidity on either side on coughing,
but no difference could be detected. The uni-
lateral and voluntary action on the arm of the
lateralus clavi is practically abolished,
the trachea edge in the should can be felt to
contract on patient coughing.
No involuntary associated movements of
face on either side on coughing if the other.
None either in the limbs, on coughing. No
spread of the response to patellar percussion,
from the side struck to the other.

Remarks. This case is one of critical degener-
question close to syphilis. The affection is
double sided. Hence not the most suitable
case for comparing phenomena on the two
sides of the body.
Case VII

A.J. Age 50.Labourer.

Complaint - Paralysis of right side of face and right limbs.

Previous History - Was a heavy drinker and smoker for some years. Never had syphilis. Always been healthy till two years ago.

Family History - No facts of importance.

Present Illness - Came on with great suddenness two years ago. Unconscious some hours. Recovery commenced a week later and continued till present condition reached.

Present Condition - A small, dark, weak man. Face has never recovered entirely. Weakness in the arm much greater than in the leg. Can move the fingers but slightly. Can flex the fore-arm 7 move at the shoulder joint only slightly. Considerable contraction of right fingers.

Heart & Lungs - normal.

Albuminuria - none.

Paresthesia & Ataxia - both present.

Reflexes - All superficial are diminished or absent. The deeps are all increased, but chiefly those on the side of the paralysis.

Associated Movements -

None in contractions on grasping or coughing. Latissimus dorsi retains its bilateral action.

No very marked movements on voluntary effort but still they (associated movements) are present. They occur with equal frequency on either side.
Case VIII

L. A. W. Age 30, Civil engineer.
Complaint: Weakness of left arm, leg and face. Stupor and mental failure. Great nervousness.

Previous History: Congestion of lungs at sixteen. Habits always regular. Moderate drinker and smoker. Thinks he had syphilis years ago.

Present Illness: Dates from 3 months ago.
Violent frontal headache for a week, followed by sudden weakness of left side, & inability to speak intelligibly. No loss of consciousness or convulsions. He was put to bed, and in the morning was able to walk dragging the left leg. Speech returned gradually, and also the lost movements but, a fortnight from his disease, the essential condition changed, patient became excitable.

Right eye shows signs of commencing aperistatic palsy. Some facial muscles acting weakly on left side.
Albinism - none
Emaciation - none
Rigidity - none
Reflexes - Slight exaggeration on left side. Plantar reflexes doubtful.

Associated Movements: The amount of
Paralysis is not great. There is evidently weakness of both sides, though the left side shows a greater degree of it. Patient's mental condition is poor, and he is unable to understand commands to perform required movements. Thus it is difficult to produce true voluntary movements, all the easier to get pure reflex ones. On examining the lower facial muscles, the left were found the weaker. On production of sudden emotion, laughter or crying, usually the latter, there was distinct addition to the movements of the paralyzed, or rather paralyzed, muscles. The two sides of the face puckered simultaneously and to an equal extent. On getting patient to try to whistle (which was not easy) or show his teeth, there was marked difference in the action of the lower facial muscles on the two sides.

This patient was troubled with a slight cough, but on no occasions were associated movements in either limbs noticed.

Case IX

Miss G. L. A mulatto woman. Aged 40.

Complaint—Paralysis of right hand. Nervousness.

Family History—No facts of importance.

Previous History—Rheumatic fever at twenty, followed by anaemia and attacks of a nervous nature. Frequently thought she was going mad. Tried dressmaking, but the
Confinement made her worse. Then became an artist model & continued, with varying states of health, in this occupation for ten years.

Nervous attacks occasionally, used to go off into a trance while posing. Her condition then became complicated by the growth of tumours, which she was told were non-malignant, if the womb. They were removed two years later.

Present Illness - Dated practically from three years ago. A sudden ‘shock’. Preceded for a week by headache and a “green feeling”. Was unconscious for two hours. Result, paralysis of right hand and arm, slight weakness of right leg and a twisted face. Recovery was gradual, but sure. Face & speech were the first. Hand never recovered. Improvement reached its maximum three months from the attack. Could turn the light, plain work with the right hand though she could not write. For two years since her condition was unaltered. Then followed a second though slight attack, three months previous to her admission to hospital. It was so slight, it felt much as if she had contracted a chill. Went to bed nothing all next next morning found the hand had relapsed to complete paralysis & that the leg was also affected.

Cranial nerves - normal.
Heart & Lungs - normal.
Albinonius - none.
Pasticity - none.
Emission - none.

Reflexes - all exaggerated on the left side, normal on the right. Plantar reflex doubtful.

Associated Movements -

Patient has complete loss of co-ordinated movement of the fingers. She has a certain amount of physical strength, more than one would expect from the extreme paresis of ability. Cannot write her name yet can grasp the hand. There is also weakness in the right leg, of the left side of the body.

Case X

H. G. Labourer. Age 47. Married.
Complaint - Weakness of right arm & leg, Palpatation.
Loss of memory. Duration 3 months.

Previous History - History of 2 attacks of rheumatic fever, the second giving rise to chronic trouble.

Family History - Mother died of consumption.

No other facts of importance.

Present Illness - Attacked while baking a cake.
Sudden giddiness followed by loss of consciousness on regaining his feet found his face twisted to the right, and loss of power on the left side of the body. Also severe frontal headache, both sides. In a fortnight improvement began. Face first, arm last. Slow improvement till admission.

Present Condition: An intelligent man. Unnaturally emaciated. Only slight movement of the left arm. Cannot hold a pen. Left leg relatively stronger. Can sit up in bed & walk with crutches. Right side seems also weaker than natural.

Lungs: normal

Heart: suprasystolic, Apex beat one inch out side nipple line. Srenal sound accentuated. Systolic murmur at apex and base.

Abdomen: slight amount.

Gastricity: none

Emaciation: none

Replaces: no unilateral difference. Not obviously exaggerated.

Associated Movements:—

A trace of old facial paralysis still remains. Patient does not show his teeth as well on the left side as on the right. More wooden appearance. This weakness disappears on coughing or laughing. On coughing & such reflex movements no associated movements occur in either upper or lower extremities of either side. Associated movements occur in both the paralyzed and the non-paralyzed extremities on voluntary motion.
of the other side. On powerful attempts to move the paralysed leg there is very marked associated movement of the right.

There is no answering jerk of the opposite leg in percussion of either patellar tendon.

There is much stronger contraction of the tendon of the latissimus dorsi muscle on angling, than on trying to induce voluntary bilateral action on the arm.

Case XI

M. H. A woman of 50. Married. Has a large family. Complaint - Paraplegia of left arm & leg. - duration six months.

Present History - Healthy till 16, then more or less anaemic for five years. Married at 24; in good health. Miscarriage at 25 (3rd month), at 26 (3rd month), 9 at 28 (7th month).


Three months later was unforced and able to walk.

Present Condition - A strong woman. Looks all right. Facial expression good. Intelligent.

Cerebral Vomiting - no abnormality. Special senses good.

Heard a Signs - normal.

Albunimuria - present in small quantity.
Spasticity - present in the paralysed limbs, & slightly.

Examination - present in left arm & left leg.

Reflexes - the deep reflexes are all exaggerated but the exaggeration is more marked on the side of the palsy, despite the rigidity these present. Clonus is easily got at the left ankle; doubtful clonus at the right. Biceps & triceps reflexes are easily obtained, & again more briskly on the left side of the body.

The superficial reflexes are present though dubious. Of these the abdominal is most marked.

There is no difference between the two sides in this class. The plantar reflex is also difficult to obtain: on the left side it is certainly extensor, on the right it is doubtful whether extensor or flexor.

Associated Movements

Are in this case most marked. In voluntary movement of either side, arm or leg, there is almost invariable associated movement in the corresponding member more especially if any movement requiring complicated coordination is attempted or performed e.g. on writing with the right or non-paralysed hand, the left forearm flexes & the fingers of the left hand extend upwards. On coughing there is invariably movement in both arms, though this is more noticeably in the left & consists mainly in a flexion of the forearm.

Percussion of tibiae produces tendon production of "jerk" both on the side struck
and on the opposite limb, provided the limbs are distinctly placed and relaxed as far as possible. Contractions in the adductor muscles of both sides is obtained or similar percussion of either patellar tendon with the humerus, heels together & thighs separated. The knees approach each other in a very marked manner. The hand grasp on the paralysed side is yield when it alone is voluntarily attempted, but there distinct occasion of rigidity of if both patients hands be held in the examiners & the patient works herself strongly.

Case XII

Mr. H. Age 63. Widow.

Complaint - Weakness of right arm and leg, mainly the hand. Duration 12 weeks.

Family History - good.

Previous History - one attack of pneumonia 10 yrs before present illness. Specific history - a 'Nebi' 5 years later.

Present Illness - No noticeable history of acet.

Had been feeling 'at 7 o'clock' troubled with headache in the mid frontal region for some days prior to his seizure. Was found in his bed unconscious, by a neighbour. Neighbours only account was that his face was very flushed, breathing shallow. The face appeared on recovering conscious vision disclosed paralysis of right arm and leg. Patient being rather unintelligent, it
In difficult to make out the relative amount of paralysis in the two limbs. She was told her face was numb.
Present Condition - on examination 12 weeks from the date of her injury.
A pale, flabby-looking, undersized woman of dignified expression. Partial paralysis of face - right side - rendered speech difficult. When she tried to say her words very slowly.
Tongue still entirely paralyzed. Left hand practically powerless & slightly enflamed & edematous. There seems to be no wasting.
Cannot voluntarily swing both arms.
Cannot bend or raise herself to sitting posture.
The grasp of both hands is weak.
Abdomen - full
Spasticity - present in the paralyzed hand which is rather enflamed. Spasticity in paralyzed leg.
Emaciation - very evident, unless general.
Reflexes - present but probably less normal.
Associated Movements
Coughing does not elicit facial expression, nor does wringing or laughing. No movements in the hand on coughing. No associated movements on voluntary effort. In fact, in this case, the examination for associated movements was futile. Though the response in the Cattell's test was greater on coughing than on attempts simulataneous act. 
Cases observed in Out-patient Department.

Eighteen cases were gone into as carefully as the circumstances & surrounding permitted. All were seen at the National Hospital, Queen's Square, with the exception of five. No full history of those will be attempted, but the results are given below in a more or less classified manner.

Sex. Eleven male. Seven female.

Extent of Paralysis. Upper arm alone — five.
Upper arm mainly but more or less leg impairment also — twelve.
Face, arm & leg — four.

No less than nine of the eighteen maintained that they were also markedly weak on the side originally unaffected, & this quite out of proportion to the debilitating influence of enforced idleness.

Age from original disease:

Over one year — five
Over three and under six — nine
Under three years — four

Wasting — More or less in all.
Spasticity — To a greater or less extent, there
was found some degree of contracture or at least rigidity in sixteen.

Reflexes

Increased on paralyzed side only — eight

" " both sides — six

Doubtful increase — three

Certainly no increase — one

Associated Movements.

Face — In this one case where there was definite was no visible associated movements in the paralyzed muscles on coughing or coughing, i.e. the paralysis was but rendered more distinct.

Latissimus Dorsi — As elsewhere observed the edge of the muscle in the axilla offered a convenient test for muscle with both unilaterally bilateral action. In three of the cases unilateral shrugging was equally well performed on either side. The remaining eleven had more or less loss of this movement. In all except one I that the contraction felt in the bords of the muscle on coughing was greater than when its patient endeavored voluntarily to throw this muscle into unilateral action.

Hand & Arm —

Associated movements observed in paralyzed hand on voluntary movement of the non-paralyzed — thirteen cases.

Associated movements observed in the non-
paralyzed hand on movement of the paralyzed — nine cases.

Associated Movements on Percussion
Joint on both sides on percussion of patellar tendon on sound limb — four cases
Joint on both sides on percussion of the same spot on the paralyzed side — two cases.
In one case there was obtained an arm joint on the opposite side in eliciting the tendon reflex in biceps & triceps on the sound side.

Evidence of Heart Disease — in three cases.

Evidence of Syphilis — in five cases.

(Though no doubt more than affected)

History of Alcoholism — admitted in six cases.
Part III

On the Literature of the Subject.

Turning to the examination of the literature on Associated Movements in Hemiplegia, the difficulty of treating separately what are really two distinct subjects becomes evident. The "paired" action of muscles must be included to a certain extent.

Associated movements in hemiplegia and the common selection of certain muscles for paralysis have been recorded and enumerated from early times. We have Bastian(10) pointing out that Culpin wrote on reflex associated movements and referred to them as Synchronisms, as far back as 1710.(11) Early in the eighteenth century we find comparatively voluminous observations in the works of Corre, Rochard, Norcross, etc.

Corre. Though there are descriptions in a sense of the muscles usually affected in a hemiplegia, we find no actual recognition of the relative paralysis of muscles with regard to their bilateral or unilateral actions. He merely refers to all. Sires, an early French writer, remarking on the fact that in certain cases, if observed early, it was possible to diagnose
the side to be affected from the unequal action of the two sides of the thorax. Of associated movement, proper Cooke gives us a description whatever.

Rock and (b) some years latter is struck by the fact that the leg is a rule recovers earlier & to a greater extent than the arm where both have been paralysed. That one side of the face is frequently paralysed & frequently recovers. Though he notices the regularity in the order & extent of recovery he is content to advance the explanation that recovery takes place where the affection has merely separated and not destroyed the brain fibre conducting impulses from the higher centres downwards. At the same time he admits that on various autopsies or localisation where the paralysis has completely disappeared enormous cicatrizes were found, & hence his explanation was insufficient. For, similarly, cases where the paralysis has persisted have displayed a complete absence of all trace of clot. No description of associated movement in any complete form is attempted.

Herzentröbli (16) in his exhaustive work on hemiplegia gives ample recognition to the innervation of certain muscles to paralysis. The rarity of impagination of the muscles of the upper face and of the chest and abdomen is commented on. Cases described where they have been affected. But again we find no description of associated movements of these. Herzentröbli concludes
Applying affections thus:

I. The Primary Aphasia & the Intracranial 

II. Those Cases only becoming gradually Aphasic 

III. The Paralytic Cases. 

Referring to class I he concludes that there 
must be in these cases some disarrangement of the 
circulation causing apoplexy by its effects on 
the cells & that this disarrangement leads to 
the effusion which has no hand in the causation 
of the stroke. In point of this he cites 
one of his cases (Case xcv) where a man of 54 
was admitted into hospital speechless & with 
palsy of the right side & paralysis on admission. 
The interosseus on one side did not act, and 
the gluteus was impaired. He died in three days 
& no disease of the brain was found except 
darkening of the choroid plexus & a doubtful 
spot of disease in the basilar artery beside which 
was a doubtful area, extremely small, of soften-

Not till the year 1866 do we find a reason-
able hypothesis advanced for the different de-
grees of paralysis of various groups of muscles.

In that year Broadbent published his elab-
orate Explanation (15) An explanation accep-
ted up till the present day almost. Towers (16) 
so recently as 1893 writes "this difference in the 
"initial palsy, & the return of power in certain " 
"muscles, manifestly suggest a complex relation " 
"of the muscles to the centres & each hemisphere," 
"& this relation is often stated by an hypothesis"
called Broadbent's but, as stated by Broad-

"But it was in form somewhat different from

"that which seems best to meet the exigencies

"of present knowledge. Its form has indeed

"changed more than once, but the credit be-

"longs to him I having first definitely stated

"it." The hypothesis advanced by Dr.

"V. H. Broadbent was as follows:—

"That when the muscles of the corresponding

"parts on opposite sides of the body constantly

"act in concert, I act independently either

"not at all or with difficulty, the nerve-nu-

"clei of these muscles are so connected by

"commisural fibres as to be part of a

"single nucleus. This combined nucleus will

"have a set of fibres from each corpus stri-

"atum and will usually be called into ac-

"tive by both, but it will be capable of being

"excited by either singly, more or less com-

"pletely according as the commissural conne-

"tion between the two halves is more or less

"perfect."

Sir Thos. Watson (17) some five years later en-

"titled Broadbent's hypnosis & considers it

"the only possible explanation both of the selective

"and evident in the muscles paralysed and of

"Associated Movements. He considers it strong

"then by the fact that in spinal hemiplegia

"where the interfering cause of the palsy is ap-

"parently beyond or below the intermediate centres

"the corresponding muscle of the several parts
is paralysed. Watson quotes in just a case re-
corded by D. Todd where such a condition followed
in a man as the result of the marginal enlarge-
ment of the oedematous process of the second
vertebra pressing on his spinal cord and flatten-
ing it. This was complete paralysis not only
of the limbs of the left side but also of the
intercostal and abdominal muscles of the
same side.

Practical discussion of Associated Movements
is rare till comparatively recent times. On
examining text-books on nervous diseases pub-
lished in different decades it is remarkable
at once how slow has been the advance in
the handling of this small subject. Ross, 17
years from the promulgation of Broadbent's theory
goes over (18) ground identical with that covered
by his predecessors. He points out various phe-
omena— the movements associated with coughing,
the influence of pressure to the paralysed hand grasp
on pressing firmly with both hands, etc. 
shows how the chump reflexes in these cases
are always increased. Then states—

"It is probable that cutaneous reflexes in—
fluences may be conveyed from the sound to
"the paralysed side through the commissural"
"fibres connecting the nerve nuclei of the two
"sides in the spinal cord. But it is equally
"possible that automatic impulses from the cere-
"bella and basal ganglia to the cerebral in-
"nuence from the cortex of the healthy hemisphere."

"<UserComment Anchor="Y" Data="47">"
may find their way to the paralysed limbs."

"Through these commissural fibres."

Here we have a definite explanation of the act of the "paralysed" action of muscles, but also of the occurrence of associated movements. But see at the same time that profitable discussion on the subject could only commence to take place as the more recent researches advanced the knowledge of the microscopic anatomy of the brain and spinal cord.

Bastian goes fairly fully into the description of associated movements. He quotes Biorand's observation on the "double-sided" response to particular percussion of one side, as alluded to and described earlier in this paper. Bastian declares that associated movement have one common feature, that they all tend to occur in hemiplegic patients in whom some amount of contraction exists in the paralyzed limbs, or else in patients in which such a condition is imminent. The imminent contraction is known by the existence in the patient of a great exaggeration of the knee jerk and ankle jerk at the presence of irritation to

"such cases are probably due to a lesion in the cerebral pyramidal tract, and the paralysed limbs are strongly in favour therefore of the existence of more or less well marked secondary degeneration in the opposite lateral columns of the spinal cord."
Coming next to still more recent times we may take the work of Sir W. Gowers as representative of the state of our knowledge of the subject in 1843. He finds there (20) an enumeration of the various forms of associated abnormal movements recapitulated. Again, as before, Broca's theory of explanation is advanced, but fewer fresh facts are given, and we have to be content with vague speculation on the means by which the subsidiary centres are able to rectify a part of the paresis caused by the lesion disconnecting from them the cortical areas on one side of the brain.

"No regards this arrangement opinion differs."

"Whether by means of pyramidal fibres that do not decussate (as by the anterior pyramidal tract, or by the passage of some fibres with the lateral columns of the same side) or whether it is by a recrossing in the cord. Degeneration may be found in both lateral columns when disease is on one side of the brain. There is a difference of opinion as to the way in which this degeneration arises, whether the fibres that degenerate come down from the medulla, as is suggested by Pflüger's observations on man, or whether they are due to a recrossing in the cord, as Sherrington concludes from his experiments on animals."

One fact is brought forward as being important, viz., the remarkable power of recovery from hemiplegia possessed by children. Gowers records
In a case where hemiplegia had occurred early in life, the patient became able to walk long distances, and had some power of movement in the hand. After death, in adult life, the opposite capsule was found destroyed. A large cavity occupied the whole of the cerebral ganglia.

Perhaps the most exhaustive treatment of the subject is associated movements and the bilateral and unilateral action of various groups of muscles is to be found in the work of M. Blanchard (21). He finds that the movements of the muscles of the face, trunk, and extremities are influenced with a wealth of detail. The comparison of their action in health with that in hemiplegia. He calls to aid the authority of numerous French authors on the subject. Harvey, Simondes, Legrand, and Rivillier on the loss of the power of unilateral voluntary action of the upper eye-lid on the hemiplegic side whilst the bilateral movement is conserved. Berger and Hallofman on the participation in certain cases of the muscles of the upper face in paralysis. Babinski, Pegliès, Raymond, and Bissando on the difficulty of proving exactly the occurrence and extent of the paralysis in the intercostal and abdominal muscles on the affected side. Blanchard, too, contributed space to the immunity from paralysis of the muscles of the upper facial region, deducing the fact that the muscles of the lower face are much
more dependent on the cortical centre than those of the lower face. It further adds to having stated that in facial paralysis of central origin the facial sensory is attached to a much lesser degree than the lower, hence it is possible to assume that the nucleus of the facial (nucleus of inferior facial of some authors) contains cells for the supply both of the upper and lower facial muscles. Only for the lower inferior: the peri-
Poland's centre constitutes the special centre, whilst for the muscles of the upper face it is only a partial centre.

Piton (22) in discussing associated movements, shows that, if the movements lost in a paralysed arm are requiring coordination account for the greater bulk. He should be noted, he says, that things a patient may be able to give a powerful squeeze to a dynamometer, registering a strength not greatly below its previous abilities yet she is quite unable to write or feed herself. Thus the dynamometer power is no index to the functional activity.

Mills (23) gives an instructive discussion on the question of these movements in hemiplegia.

After enumerating the various forms met with he proceeds to state the following facts bearing on it:

1. Associated movements are most frequently observed in the upper extremity.
2. Of 20 cases studied in hospital 20 showed associated or substituted movements.
iii Of these 25 cases it was found that
(a) In 10, voluntary movements on the un-
affected side caused involuntary move-
ments of the paralyzed side.
(b) In 11, movements or attempted move-
ments of the paralyzed limb caused in-
volutary movements on the other side.
(c) In 4, the movements were of special
character.

Nearly all the results were obtained from
the upper extremity. In one, attempts to
move the the paralyzed arm caused move-
ments of the paralyzed leg. In another,
coughing caused the paralyzed arm to be
moved to the face. In a third, yawning
was followed by an extension of the
paralyzed fingers, etc.

While thus proceeds to discuss the various
explanations which have been suggested
of these phenomena. His remarks on this
head, however, may be left to the follow-
ing chapter.
PART IV

On the Causation and Nature of Associated Movements.

Our knowledge of the causation of associated movements is at once vague and theoretical. No methods of research have shown conclusively any special lesion post mortem which can be proved to be the cause of them. At present we have to be content to piece together the various items of evidence and hope in the course of time to be led by this means to a clue which in turn will lead to definite proof and demonstration of the structure implicated.

In the first place it seems evident that those movements which are here described as associated movements, movements produced independent of Will stimuli but frequently occurring in connection with willful movements of the corresponding part of the body on the unaffected side, are what may be described for convenience as movements of a more highly differentiated character than smiles associated and reflex movements observed in animals of a lower evolution than man, given a similar pathological state.
It is found on examination that the lower we enquire in the scale of' evolution, the less do we find the preponderating influence of the brain in the movements of the animal, the more do they appear to be automatic and reflex. Apart from the subjective evidence obtained by actual observation of the various movements, we have definite objective evidence of the greater isolation, as it were, of the brain in the gradual lessening in importance of the pyramidal tracts as we advance the scale.

For example. A frog with cerebral hemispheres removed has movements exactly similar to those of an entire frog except that they need an external stimulus to bring them forth. It can be made to swim, leap, and crawl. Muscular movements are determined by different influences proceeding from the muscles and constituting the foundation of the muscular sense (23). Foster insists on the fact that in the frog the nervous machinery required for the execution as distinguished from the origination of bodily movements is such as to require the cooperation of highly differentiated afferent impulses. Similarly, physiological experiments have shown that in the dog if both pyramids in the bulb have been cut and thus the cortex not damaged,
both pyramidal tracts below the cut degenerate.
Such a dog, after recovery from operation, through
no regeneration of the tract takes place, is able
apparently to execute all the ordinary voluntary
movements of which a dog is capable. Obviously
in such a case the will has access by other
paths than the pyramidal tracts to the special
mechanism.

These examples are sufficient to show what is
above stated. As the lower one appears in the
scale of evolution the more independent is the
animal apparently of its own brain. As we
come higher, similarly, voluntary acts apart from
reflexaneous movements become more conscious.
It has been shown by experiment that a
dog operated on so as to sever the connection
of the cortical centres with the limbs of one
side soon recourse to runs about apparently
unaffected. But if the same dog be held up
and approached too near for comfort day to
the bars of a hot fire-place the limbs on the
side left connected with the brain are alone
drawn up. Here the animal is called upon to
voluntarily draw up his limbs to escape the
heat & proves itself incapable of voluntary
motion on the affected side. Proving that
such automatic acts as running & leaping
are performed either without command or
injury from the brain itself or else such com-
mand can travel downwards to the spinal me-
chanism by other paths than the pyramidal tracts.
Let us now turn to a study of movements observed in the human infant. It is found that in many respects we have the a similar state of matters. In a most interesting and instructive paper to Mummford (26) draws attention to Survival Movements of Human Infancy. He points out that in infancy spontaneous or involuntary movements occur, purposeless in character and widely differing from the voluntary movements of later date. They steadily diminish in number and importance till the end of the 6th or 7th month. These early movements are probably vestiges of functions of limbs which were of prime importance to the members of the race at another and early period of its growth. Mummford describes 4 kinds:

i. Impulsive or Spontaneous Movements, e.g. stretching, yawning.

ii. Reflex Movements - breathing, swallowing.

iii. Instinctive Movements - running, walking.

iv. Voluntary & Intelligent Movements - All acquired & preceded by an idea.

"Primitive man was aquatic and therefore the "hand must have been a paddle. Then, the "various food of land tempting him, man "became arboreal, the limbs then changed to "accommodate to the different foods."

Mummford points out very clearly how many of the early infantile movements, spontaneous in character, are bilateral & automatic in tone.
Some pursue through life in association with certain acts.

"The primitive position of an infant's hands is" as follows. They are folded on the chest: the thumb towards the head, palm towards the nape; more often the palm is away from the chest wall. As the child wakes up, the elbows begin to open out and the palm is pushed outward in a way that would be useful in locomotion especially in a fluid medium.

In fact, paddle-movement. Slow rhythmical movement of flexion and extension of the fingers occurs, with the sluggish rhythm so familiar to our visitors to the aquarium. As the fingers become fully extended a rotating movement of the wrist occurs by which the ulna bone and little finger knuckle are lifted upwards as in "raising a cup to the mouth", though the elbow joint becomes extended instead of flexed.

The hand is thus moved backwards and outwards as a paddle would be in swimming. The whole of this movement persists throughout life, associated with the act of feeding.

In the body we easily find proof of the absence of coordinated movements. In tickling the palms or soles the fingers or toes contract automatically to seize the irritant. It is at once noticeable that the baby makes no use of the thumb. In trying to lift a cup the thumb is used in the same manner as the other fingers. In the majority of children
the thumb is found to be not fully used up till the eleventh month of life. The same is the case with regard to the use of the four-finger in Punching.

It is thus easy to trace out an evolution of movements as in the case of all other things. Roughly speaking if we go back far enough in the scale of life we come to a time when all movements of the central are apparently automatic and involuntary. There is no right side and left side. Nothing but an indeterminate mass of protoplasm with but the most primitive means of propulsion. Later we have the division into left side and right side, more highly evolved though still automatic movements of the rudiments of brain control. Still we come to such animals as the dog or the horse or the human infant where, though most of the movements are automatic, the dominance of the will is clearly evident.

That the dog recovers all its apparent powers after the severance of one hemisphere has been proved by physiology. That the child has enormous powers of recuperation is proved by the remarkable recoveries recorded in the case of many infantile hemiplegics.

Then we come to mature man, the highest product of evolution, where the vast majority of movements are of a highly differentiated character and necessitating the constant and skilled attention of a highly trained
A corresponding state of matters is found in examining the brain, spinal cord and the connecting tracts. From the most rudiments I all trace to the dog where both are apparently far advanced in development yet removal of large portions of the hemispheres seems to affect only moderately from the former of the animal in the way of locomotion and to man where even the smallest lesion of the connecting tracts on one side causes irreparable and only too evident damage. It is in man that we find the most highly developed system both of cerebral and other centres and of the communicating and connecting tracts. Relative the pyramidal tracts in man are vastly greater in size than in the dog, and just as in man it is only as grown from the infant proceeds that the more highly differentiated movements appear, so it is only as the infant grows that the pyramidal tracts become medullated and functional.

It has been held that associated movements may be due to the existence of that portion of the pyramidal tract which does not accessible in the medulla. As regards the anatomy of the termination of the fibres of the direct pyramidal tract we find considerable variance of opinion. The motor path in the brain and spinal cord has now been most elaborately
worked out. Secondary degeneration affords a means of following it with the utmost precision, tracing the fibres to their starting point in the central convolutions. According to Sowers (26) the pyramidal fibres extend from these convolutions to the spinal cord without any interruption if by grey matter.

Each lateral tract crosses the middle line at the decussation in the medulla, joining with the direct tract, forms the anterior pyramid. The two pyramids enter the pons and divide into various portions. These course up through the pons, surrounded by much grey matter with which they have no connection, unite once more and ascend by means of the crus cerebri and lenticular nucleus to the cortex. The motor impulses originating in these convolutions appear to be conducted directly to the grey matter of the spinal cord by these fibres, without the intervention of any nerve cells, either of the central ganglia in the pons, etc. Again, "during the descent each tract decussates in the medulla of the opposite side to descend as the crossed "pyramidal tract" but each leaves behind, as it were, a small bundle of fibres which does not decussate, but continues its descent as the direct pyramidal tract. Whether the fibres of this portion eventually decussate before they communicate with cells of the "peripheral nuclei is still a matter disputed."
"We have here, therefore, a possible means of communication between the hemispheres of one side and the various cells of the peripheral nervous of the same side, and hence a possible bilateral communication.

J. T. (27) says in reference to this matter, "The centre for movements of the trunk is said to be situated in the superior frontal convolutions. It is probable that the pathway originates in the hemispheres both of the same and of the opposite side. In the same way other muscles whose functions are bilateral (eye, arm, etc.) probably derive their innervation from the hemispheres both of the same and of the opposite side. But our knowledge of these uncrossed or double crossed central pathways in man is very imperfect."

The ultimate decussation of the anterior pyramidsamidal tract has recently been disputed, "with some reason, as it has been supposed that the tract ends in the anterior horn of the same side.

Ormerod (28) quotes Ribot (29) as having made some important anatomical investigations on the subject which still left the question in doubt. Of ten cases of unilateral cerebral lesion with descending degeneration which he examined post mortem, there was in one instance degeneration of both crossed pyramidal tracts from the decussation in the medulla downwards. Though paraplegic phenomena
would have been expected in these cases. The contraction during life was limited to the hemiplegic side.

Quain again (30) maintains that it is highly probable that the decussation of the anterior pyramidal tracts goes on along their whole course, the fibres reaching the lateral pyramidal tracts on the other side of the cord. The decussating fibres in the anterior commissure thus forming a continuation of the lateral decussation in the medulla oblongata.

Halliburton (31) also "A smaller collection" "If the pyramidal fibres goes straight on, on" "the same side of the cord, and those cross at" "different levels in the anterior commissure of" "the cord lower down, hence the disappearance" "If the direct pyramidal tract in the lower" "part of the cord."

If one works from the hypothesis that a small proportion of the motor tract does not decussate but serves as a means of communication with the lower or peripheral nerves, one is faced with the fact that either this small tract is not habitually used by the hemispheres or else, if it is in constant requisition, one ought invariably to discover not only a marked paralysis on the hemiplegic side, but also a lesser amount on the supposed unaffected side. That this is really the case is not difficult to prove. Few suffer from hemiplegia are met with who on being
Carefully questioned and examined, cannot give definite proof of the point. The dynamo-
meter frequently records a remarkably 
small result from the finest grasp by the 
unparalyzed hand.

Whatever conclusion is come to in the future
on the question of the reeducation of the fibers
of the anterior pyramidal tract, at present the
point must be left open, the clinical features
of the cases exhibiting associated movements
must be closely examined with a view to elic-
ting a clue to their causation.

Of the 12 cases described at length there were
trace of movements in 6, marked movements
in 3. Of the remaining 18 cases seen in the
outpatient department, 13 showed more or
less the presence of associated movements. In
all these cases the deep reflexes were markedly
increased. Associated movements were
rarely found in cases where there was no
increase of these reflexes, or in nearly all was
there some rigidity of the affected limbs.

In three cases where there was no contractions,
trace of movements were found. In one,
(Case XIII) there was found spasticity with
its movements.

Three cases of the twelve fully recorded
showed marked associated movements of
cold limbs. Of these one was an old syphilitic,
one had malarial disease, one phthisis.

The accompanying table perhaps gives a
<table>
<thead>
<tr>
<th>No.</th>
<th>Age</th>
<th>Sex</th>
<th>No. of Attack</th>
<th>Date from Seizure</th>
<th>Albuminuria</th>
<th>Atrophy</th>
<th>Deep Contracture</th>
<th>Previous History</th>
<th>Associated Movements</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.68</td>
<td>M.</td>
<td>1st</td>
<td>3 months</td>
<td>+ marked ++</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Present but not to any great extent</td>
<td>Arthritis, tortuous</td>
</tr>
<tr>
<td>2.61</td>
<td>M</td>
<td>1st</td>
<td>3 months</td>
<td>-</td>
<td>-</td>
<td>normal</td>
<td>-</td>
<td>Possibly alcoholic</td>
<td>Home, at doubtful</td>
<td>Probably an hemorrage</td>
</tr>
<tr>
<td>3.62</td>
<td>F</td>
<td>2nd</td>
<td>2 weeks</td>
<td>+ present ++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Echymotic plaque, Neural stiffness Marked and of all kinds. for voluntary movements &amp; reflex.</td>
<td>Embolism</td>
</tr>
<tr>
<td>4.63</td>
<td>F</td>
<td>1st</td>
<td>3 yrs</td>
<td>- present ++</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Only traces</td>
<td>Congenital Syphilis</td>
</tr>
<tr>
<td>5.64</td>
<td>M</td>
<td>1st</td>
<td>6 mos</td>
<td>Trace marked ++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Only traces</td>
<td>Arterial Aneurysm. marked in both optic discos.</td>
</tr>
<tr>
<td>6.66</td>
<td>M</td>
<td>3rd</td>
<td>10 mos</td>
<td>Trace present ++</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>Ulceration lq., Sph. 1</td>
<td>None</td>
</tr>
<tr>
<td>7.67</td>
<td>M</td>
<td>1st</td>
<td>2 yrs</td>
<td>- present ++</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td>Only traces</td>
<td>Miliary weaknesses. Difficult case to examine for associated movements</td>
</tr>
<tr>
<td>8.68</td>
<td>M</td>
<td>1st</td>
<td>3 yrs</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Pneumonia</td>
<td>Only traces</td>
<td></td>
</tr>
<tr>
<td>9.69</td>
<td>F</td>
<td>1st</td>
<td>3 yrs</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td></td>
<td></td>
<td>Rheumatic fever,</td>
<td>Home</td>
</tr>
<tr>
<td>10.69</td>
<td>M</td>
<td>1st</td>
<td>3 months</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td></td>
<td></td>
<td>Rheumatic fever. Heart disease</td>
<td>Distinct though not marked.</td>
</tr>
<tr>
<td>11.70</td>
<td>F</td>
<td>1st</td>
<td>6 months</td>
<td>+ slight ++</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>Nervous. All forms.</td>
<td>Marked.</td>
</tr>
<tr>
<td>12.70</td>
<td>F</td>
<td>2nd</td>
<td>3 months</td>
<td>Trace</td>
<td>-</td>
<td>+</td>
<td></td>
<td></td>
<td>None</td>
<td>Probably Syphilitic</td>
</tr>
</tbody>
</table>

This table lists the details of various cases, including the age, sex, number of attacks, date from seizure, albuminuria, atrophy, deep contracture, previous history, associated movements, and remarks.
better view of the various facts. How is one finds it impossible to discover any constant conditions apart from increase in the deep reflexes and perhaps contracture. Albuminuria, present in certain proportion, had no bearing on the subject. Age declined nothing. Of the three cases with marked movements, none were older than 50; one was a girl of 26.

 Apparently they do not develop, however, soon after the seizure. There seem to be a period up till the time when the deep reflexes commence to increase when associated movements are not found, but in some cases even the corpus callosum & the presence of exaggerated reflexes and contracture fail to produce the phenomenon. In one out-patient no fewer than fourteen years had elapsed & yet none were observed.

 Try as one may, the clinical facts on observation show no hope of clarifying the question, and the more one studies at elucidation the more one is driven to depend on the microscopic appearances of the nervous structures obtained post-mortem and on the gradual development of the appearances discovered by pathologists in their various experiments.

 In an interesting paper by Molt & Gieser in ‘Brain’ (38), the results of electrical stimulation of the corpus callosum are described.

 On passing the electrodes carefully into the great longitudinal fissure between the hemi-

spheres
and stimulating the upper surface, bilateral movements of head, trunk & limbs according to the part touched, were obtained. That these movements were due to stimulation of the fibres & not to a spread of the current to the motor surface of the cortex was proved:

(a) by the results following very weak currents,
(b) by slightly withdrawing the electrodes, with cessation of results.

When the grey 'motor' tract became on one side was destroyed by actual cutting, the movements became unilateral.

The general results obtained were:

(i) That the corpus callosum carries fibres the excitation of which produces movements of both sides of the body.
(ii) That these fibres do not pass directly from the corpus callosum to the internal capsule but enter grey cortex of hemispheres and come into connection with the so-called 'motor cortex.'

Hills (93) discusses the various suggestions advanced for the explanation of associated movements. He includes the following:

i. Increased excitability of the centres and diminished resistance of the tracts connecting the centres through which these movements are produced.

ii. Transference of reflexes.

iii. Breakdown of normal impulses.

iv. Loss of inhibiting power.
Beyond theorising, we attempt to solve the question: are B anyavail. On the one hand we detect a break in the connecting link between the motor areas B one cortex and the muscles supplied by them, on the other we have the presence of definite and unexplainable movements of these muscles.

Looked at broadly, one of these causes must be operating:
(a) The centres cut B must find other paths by means of which they can send downwards their messages, or,
(b) Other portion of the cortex, probably the corresponding centres of the opposite side, must take on fresh duties, or,
(c) There must be a storing up of latent energy in the muscles themselves or in the whole peripheral nervous system which results in sudden discharge of energy -- the full cup, as it were, overflowing.

Hence the microscopic anatomy of pathological and physiological specimens has advanced some stages further, no definite part of the causation of associated movements in hemiplegia can be arrived at.
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