On the Summation of Electrical Fluxes applied to the Skin.

By

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Part II.

Original Experiments and Observations

1875.
Description of the Arrangement of the Experiment and Apparatus.

The most complete arrangement of the experiment, which served for a great part of the investigation, is rendered plainly in the appended schema (Fig. 1).

Three pens \( F_1, F_2, F_3 \) write with leaden will upon the endless coil of paper on a thermographium or where cylinders move with great precision. The three pens are placed directly above each other and as long as they are at rest they write horizontal parallel straight lines. The lowest pen \( F_1 \) is drawn downward for about one and a half means of an electro-magnet as long as the second pendulum \( P_2 \) at the end of each vibration completes.
the closure of the time-marking
circuit (........).
The middle pen $F_{11}$ is connected with
a secondary closure ($S_{11}$) which is intro-
duced into the induced current (........)
circuit. As long as the key is depressed
keeping the pen $F_{11}$ also depressed, it con-
ducts the current away from the preparation,
which is therefore stimulated as long
as the line drawn by $F_{11}$ is elongated.
The uppermost pen $F_{121}$ rises up, being elevated
by the counterforce $G_{1}$, as soon as the foot of
the frog ($F_{1}$) is withdrawn from a plate
described in Rapt's paper (Tr. Rapt. Arb.
The plate is attached to the lever ($L_{1}$)
The electric stimuli which occasioned
the reflex movements of the limbs, were applied
or conducted to the skin of the foot by two
loops $D_{1}$, of fine gold wire, which were
separated from each other by a distance of
about 5 mm. These loops surrounded the
ankle joints, without however constraining the
skin. The wires were well isolated by sheet-
cavatone being several layers, made fast
to them by means of Chloroform, which is
an excellent solvent for this purpose.
The wires were connected to the pole
of the secondary spiral of a du Bois
Reynolds Induction machine. The Currents
in the primary journal (S.) kept up by the
Grune's elements, was broken and opened
at the mercury contact C. at regular
intervals by means of a Ruhmkorff's
interruptor (7.) The wires L and M
conduct the primary current to t from
the interruptor, whose essential part is
here figured. The commutator at "m"
cannot be used for opening or closing the
current, whilst the key "k" was not required
for this arrangement of the apparatus.
The transverse bar "q" carrying a platinum
point reaches to the mercury contact "O" from
which it is withdrawn when the
other end of the transverse bar "P" is
attracted by the electro-magnet "i". The
contact "s" then severed breaks the current,
renders the electro-magnet powerless; the
transverse bar springs back again, and
the vibration is commenced and continued
as in the case of a Magneto's hammer in an
ordinary induction machine. By means
of the weight "h" which moves upon the
pivot rod attached to the transverse bar,
the duration of each vibration of the pendu-
lum can be varied between the limits
of 2" - 15". The small screw "0" which can
be raised or depressed, so regulates the
length of the pendulum so that whilst the pendulum is at rest,
contact just exists; i.e. an open
metronome.
Induction shock would be produced as soon as the electromagnet is set into action; after 44 vibrations the contact is again opened (closing shock); after again 44 vibrations (when the style dips in and out of the mercury) an opening shock takes place, i.e., in equal intervals of half the duration of a vibration, it has alternately one opening and one closing shock. In that a good secondary close, changeable at will, can be made or omitted (analogous to Helmholtz's arrangement in the induction-machines) by means of the vibrating bar, one may obtain the induction current in the opposite direction as of tolerably equal intensity. The spark at the opening never disappears completely.

The Washington apparatus. Fig. 2.

This apparatus is intended to keep clean the mercury contact (C. in Fig. 1) from the isolated particles, which are formed by the unavoidable spark at points where the primary current is broken, which influence the constant completeness of the resistance of the wires with the intensity of the current. The layer of alcohol, which following the suggestion of Poggendorff (Annalen 18, p. 94, 289) stands above the mercury, to diminish the spark from
the breaking of the current is being constantly
rendered dry by the fine particles of oxygen
mercury. It must, therefore, be constantly
renewed. This is accomplished by a fine
stream which runs into the contact-tube.
0.25 from a small funnel b, filled with
dilute alcohol. (1. Through the glass-tube
a, provided with a stop-cock.) The
outflow, by means of the syphon f, is
so regulated, that the circulating
alcohol remains at about a height of
1 cm. above the level of the mercury.
In order that the small funnel may
be always filled near to the margin,
i.e. the supply for the stream may be
kept constant, a small Mariotte
flask is placed above it. Through the
bottom of the flask a glass tube of 0.25
cm. diameter, is introduced and made watertight.
This tube projects for about 2 cm. into
the cavity of the flask. A conical pointed
glass rod is placed in the tube to act as
a valve (moveable). The pointed end of the
rod projects below a little beyond the tube
so that it is elevated by the wall of the
funnel as soon as the flask is placed
on the funnel. An ascending tube of
about 1 cm. in diameter fills the second
hole in the bottom of the flask, and is
an obliquely ground mouth about 1 cm.
below the bottom of the flask, whilst the upper end reaches to the air space above in the Mariotte's flask. If the flask is filled to the upper opening of the ascending tube, it placed upon the funnel & that the contents of the flask run into the funnel, until the opening (lower) of the ascending tube is closed by the level of the fluid. Then, by the presence of the outer atmosphere, which cannot equalize that of the air contained within the flask, hinder the fluid from passing through the valve, until the level
of the fluid in the funnel eills allow bubbles of air to ascend through the ascending tube. Thus the level of the fluid is kept constant, just under the orifice of the funnel.

The other parts indicated in the figure of Ruhmkorff's Interrupter will be referred to in their proper place in the text.

To imitate the chemical stimulation with the help of electric stimulation I began with applying to the limits of a immersed frog's nerve, frequent electric stimuli. The magnet, hammer on the inducement of Dr. Pois Raymond, later a König's tuning fork which vibrated 100 complete sounds a second, also a vibrating rod of steel (made out of an old dwelling) were the means by which the primary current was interrupted. Minimal stimuli acted after very short latent stimulation, and soon lost their effect, if half a minute, rest was not given between the periods of stimulation. Strengthened currents produced reflex contractions after very short latent stimulation. If such discharges of reflex activity were often produced in pauses of from 2 to 10 seconds, then the times of latent stimulation increased.
to 3 seconds, or exceptionally to 5 seconds. The reflex contractions were at the same time weaker. The duration of the latent period could not be materially changed by strengthening the frequent stimuli. When ineffective stimuli were rapidly strengthened, then the reflex movements occurred with an intensity of the current, which remained powerless, when the currents were gradually increased to the same degree.

The often confirmed observation, that the maximal reflex contraction produced by frequent stimuli occurs after a short latent period, and that strengthened stimuli are not able essentially to shorten the latent period, seem to point to this, that the great difference in the duration of the latent period, if caused by only the intensity of the very frequent impulses, remains the same.

I therefore sought to observe the influence of changed frequencies of stimulation. New vibrations of Paget's hammer afforded an occasion to distinctly elevate the limb, or mental later, than the rapid succession beats with high-tuned earring. This result, however, was only doubtful, and perhaps might be caused by irregularities in the contact.
Even when I gave the limb only 45 Shocks in the second, I observed little difference or no great difference in the latent period, whether the stimuli were strong or weak, only the size of the Contractile increased with the strength of the current. The latent-period first, after the fatigue had made itself obvios, in that it occurred the duration of the latent-period for equal strong stimuli. The following table may serve as an example of the fact cited.

At the outset of the corresponding experiments, addition follow stimuli of different-intensities were compared. In such, the latent-period was essentially lengthened, when the strength of the currents were diminished.
Table I

Between each two observations, unless noted to the contrary, is 2 Min. Rest.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Internal</th>
<th>Strength of Stimulation (Units)</th>
<th>Latent Period (Seconds)</th>
<th>Interval</th>
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The different strengths or degrees of reflex contraction, I have divided into four grades in this way, (partly also for convenience in the tabular arrangement). Grade I. means raising of the foot alone. Grade II. flexion of the leg at the knee joint. Grade III. flexion of the thigh together with the leg (flexor of the knee joint). Grade IV. notable repeated spasms of one or both lower extremities.

As under the rubric "degree of contraction" means that in the corresponding period of stimulation, no reflex action occurred. The rubric "under the rubric, "latent periods" shows equally that the expected contraction did not occur.

These examples are chosen, because in the one case the latent periods in spite of moderately strong frequent stimuli soon become large, only with long intervals between the weak stimuli becoming marked. Lengthening in the other case with rapid succession of stimuli, however, have small values until the preparation is near to death. In both series no dependence of the latent periods on the intensity of frequent stimulation is to be observed. The stimuli must be gradually increased, in order to obtain results, and also act much longer, before they produce a contraction.
Table II.

<table>
<thead>
<tr>
<th>Period of Rest between the Previous Stimulation</th>
<th>Intensity of Latent Stimulation</th>
<th>Degree of Contracture</th>
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<td>30 Seconds</td>
<td>1/3&quot;</td>
<td>0.2&quot;</td>
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<td></td>
<td>1/6&quot; Int.</td>
<td>0.4&quot;</td>
</tr>
<tr>
<td>10 Minutes</td>
<td>1/3&quot;</td>
<td>0.2&quot;</td>
</tr>
<tr>
<td>30 Seconds</td>
<td>1/6&quot; Int.</td>
<td>0.4&quot;</td>
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</table>

This table shows how with small intervals of stimulation, the time of latent stimulation are independent of the strength of the stimulus, while the degree of tail of the contraction however varies.
Even before the duration of latent stimulation has reached 2 seconds, the sensibility is generally attained. The contractions become at the same time small, i.e. all the foot is still raised. This coincides with the observations of Volkman (Müller's Arch. f. Anat. u. Phys. 1838 p. 23.) "da die Ausdehnung der Reizbewegungen von jüngster Zeit der Stärke der Reizung und von dem Grade der Reizbarkeit abhängig sei."

The above cited difference in the sensibility of different-frogs, led me to investigate the point, whether perhaps the irritability of the spinal cord changes with the altered condition of the life of the animal. Impressed with the investigations of Lenbe (Recherches de Bois Rey and Arch. 1867.) conducted under Rosenbli't's direction, I further investigated by Usseritsky (Reichs. de Bois Arch. 1868) that aphana (produced by strong respiration) suppressed the reflex transmission in the spinal cord, I attempted by profound respiration or ventilation of the lungs to influence the reflex processes. Although the effect of artificial inflation of the lungs in frogs was expected to be small, on account of the very complete cutaneous respiration in these animals, compared with what is observed in
Mammals, still a small result might have been expected with the sensitive method for estimating the strength of the stimuli, for estimating the period of latent stimulation. In a long series of experiments, a glass cannula was introduced through the sinus fistulae, to reach the brecchia of the previously prepared frog. The lungs were rhythmically inflated by a regulated current of air.

In the intervals, during which, by means of a column of water, the inspiratory pressure was kept constant, by means of Bowditch's electro-motor cipho-coil (Erbe's Ann. der Phys. vol. 25) (1871), the air was admitted or cut off from the lungs, the expanded lungs could expel their contents through the well-known Rosenthal's lateral opening in the cannula. Many comparative experiments, however, convinced me that artificial respiration, of different depth, of varying frequency, exercised no effect or rather I should say influence on the reflex processes in frogs. On the contrary, most of the preparations, which lasted some time, showed at the beginning an increase of excitability, the experim. was begun at from 1/4 to 1/2 an hour after the section of the spinal cord.
Also in many cases, in fresh preparation, (frischer) it has clearly be observed, that weak stimuli after strong ones, were more effective than before them, i.e. there caused modifications in the irritability, as was observed by Trousseau (Recherches sur les fous, Arch. 1859, p. 537) on motor nerves by Trüb (J. phys. Soc. Med. Acad. d. Freeswich 1857, No. 2.) later by Dr. Baxt, (l. c. p. 74) on reflex preparation, with chemical stimuli.

Later, it is general the irritability unite with the time, but with very rapid even in frogs kept under similar external conditions. Thus, frogs with divided spinal cord, which had at first received a few trials stimuli, might be dead even in half an hour, whilst others had preserved their irritability of the highest degree, even for 30 hours after their preparation.

Several frogs were so extraordinary sensitive, that they, even after destruction of the brain, after section of the spinal cord below the lumbosacral plexus, after the section had been contused by a piece of iron wire, were able upon being hung up, to execute spontaneous movements. Such a reflex-frog then reacts upon very weak electrical stimuli. Sometimes it happens also, that at once, after a
Series of ineffective stimuli has been interrupted, that violent movements follow. These are due to the occurrence of excitations which are foreign to the experiment.

Such a summation of two stimulating different stimuli (e.g. electric & mechanical, or chemical) may be produced artificially, and thus render the individual sub-minimal stimuli capable of producing reflex movements.

Such anomaly however did not often do both the course of an experiment. The rule is, that the limb, together with the part of the spinal cord from which it depends, hangs motionless, until an external stimulus of sufficient strength meets it. The often it is stimulated, the stronger the impulse, must be to cause reflex movement. The shorter the period of rest between the individual stimuli, the more rapidly is the excitability lost. The excitability can however be kept constant for a long time, when one makes the duration of the period of rest from 3 to 10 minutes.

Long periods of rest bring with them a drawback, viz. that the duration of a single experiment becomes very long, and often a rapid progressing death.
does not permit of the comparison of the later series in the experiment with the former results. In most cases, therefore, I found it useful to introduce 5 to 2 minutes between the observations, only in exceptional cases, after very fatiguing period of stimulation, to give longer rest. The fatigue then progresses very slowly, and its effects are easily distinguished from the other conditions of the experiment.

After having found that, with rapid succession of stimuli, the extent or strength of the reflex, built up the latent time, changed with the intensity of the stimuli, I tested the effect of varying the strength of the current, with moderate frequency of stimulation. By means of the Ruhmkorff Interruptor arranged in 2. (Fig. 2), with the help of a vibrating glass, I allowed the primary circuit of the inductorium to open and close at intervals of from 1/2 to 1/15th a second. On employing moderate intervals of stimulation (1/2 to 1/15) the latent stimulation constantly diminished, when the strength of the stimulus was increased. The following table shows, how the time of latent
Stimulation varies with the intensity of the current.

In that the laws which regulate the dependence of the two cited factors cannot be formulated precisely, but as the direction of the approximate extent of the change in different stages of fatigue can easily be tested by every physiologist, I shall not take up time to repeat by giving a repetition of many series of experiments, as occasioning the experiments to be cited later upon implicitly confirms the above results. Still I cannot omit to remark that in my first-series of experiments, there are some times, animals, where with unchanged intensity of current the time of latent stimulation varies within wide limits. On account of such marked irregularities, which can only occur when the current closure does not take place exact equally, it is always necessary to test the results of the theories repeatedly, as was the case in the following example.
<table>
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<th>Interval</th>
<th>Strength</th>
<th>Relation of Strength</th>
<th>Latent period</th>
<th>Degree of Confidence</th>
<th>Interval</th>
<th>Strength</th>
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<td>III</td>
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<td>1.10</td>
<td>1.51</td>
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<td>1.20</td>
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<td>III</td>
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<td>1.11</td>
<td>III</td>
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<td>1.12</td>
<td>1.14</td>
<td>III</td>
</tr>
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<td>1.14</td>
<td>III</td>
<td>28</td>
<td>150</td>
<td>1.20</td>
<td>1.14</td>
<td>III</td>
</tr>
</tbody>
</table>

*Note: Degrees of confidence range from I (highest) to III (lowest).*
<p>| Interval of | Strength of | Relation of | Latent-period | Degree of |</p>
<table>
<thead>
<tr>
<th>Stimulation</th>
<th>Stimulus in</th>
<th>Stimulation</th>
<th>in Seconds</th>
<th>Construction</th>
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<td>2.0:1</td>
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</tr>
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<td>0.8</td>
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</table>

End of the Experiment.

Note: This table shows the dependence of the time of latent stimulation and the degree of contraction upon the intensity of the stimulating current stimulating at moderate intervals.
That plan casually remarked in the first half of the table formerly given, is very clearly pronounced in this one (Tab. II), that the latent period diminishes whilst the strengths of the stimuli increase. To make more plain the relation between the increase in the stimuli and the times of latent contraction, I have reckoned the quotients of two neighbouring intensities, & also the quotients of each two consecutive latent periods, & placed their values between the times of the two corresponding finer data.

If one now compares the relations of the strength of the stimuli with the reciprocally proportional numbers of the latent periods, at the same height, it is to be observed in general that the values of equal neighbouring stimuli correspond to tolerably equal amount of latent periods, or rather, it would be better expressed by saying that tolerably similar latent-values correspond to the values of similar neighbouring stimuli. In a few cases deviations are to be found, which however only become considerable when the stimulating temps is changed, &此事, which I shall have occasion to mention further on. The obvious inconsistency of the results, which is sometimes, & be observed, are not the ascribed to any method of experimenting, which certainty
are certainly capable of many improve-1t's to the variability of nervous structure.
Even the branches of the motor nerves, the
investigated with the most perfect-me-
ner stimuli, with electrical currents of
peak intensity, do not always produce
the corresponding muscles, contractile
of exactly equal height.
In spite of the above mentioned in-
with similar relations, still one can ob-
serve the already cited fact, that af-
several stimulation, the excitability no-
concentration, so that, e.g. 80 units (E) in
a 1.8-2.0" *afterwards only 1.4"-1
before they produce a reflex action
that 70 E produce the effect, which
prevents 60 E has. From however,
times of latent stimulation again
20 that the strength of stimulus 125 E
at first increases, leading to a latent pe-
or 1.0", then to 0.7"-0.8", later, still eq-
ivalent (4") has the numbers 0.9"-1
-1.7" belonging to it.
Apart altogether from each mod-
of the excitability, we find, that, with
the values of the quotients of the stim-
duration from 1, the quotients of the
latent period also vary, i.e. that in
opposite direction, so that decreased
latent periods correspond to increases.
But it is also to be observed, that by no means, as one might have expected, are the 
guiding- -of the stimulus latent-guiding- of similar series factors really 
reciprocal to each. Therefore examine the single 
values with the exception of the stimulus 4-8, 
which shows great anomalies.) More closely 
we find that with a moderate change in 
the intensity of the stimulus, the relations 
of the corresponding times do not materially 
depart from those expected; that when the 
stimulus is varied considerably, the latent 
periods change in a still higher degree ( 
8° 17 to 21). A further increase of these 
(differences between the corresponding values 
of the relative values in the two middle 
columns due to be found in 8° 23 + 24. 
Then we observe that with progressive 
fatigue, nearly equal, may sometimes 
smaller latent quotients (of course always 
reciprocal) correspond to the large 
stimuli-quotients.

As induction currents of 125 E in spite 
of greater frequency become almost ineffective 
(8° 35), it now an 150E in the series of effective 
stimuli-essentially an increase of 25 E, the relative 
numbers of the latent periods, reach a much 
higher values than had weaker stimuli 
of equal frequency whose intensity had 
differed by 25 E. Each the adequate
Intensity of the current (150 E) was increased only 10 E; the latent periods increased quite proportionally, whilst a further increase of stimulus of 15 E only slightly shortened the latent period by a little. In the further course of the experiments, with always similar relations of the stimuli, the relations of the latent periods increase or that they reach the value 4:1 (8:66).

Ultimately 1:6 of the latent periods of the weaker stimulus increase considerably, whilst those of the stronger stimulus remain tolerably unaltered. According to this then, the times of latent stimulation are by no means simple functions of the strength of the stimulus, like the height of a current in a barometer, the stimulation of the motor nerves, but quite different-values correspond to equal increase in the stimuli under different degrees of excitability in the same reflex preparation. The result of the observations may be formulated thus: only a small limit exists between the marginal stimuli (with short latent periods) the marginal one, with long latent periods. If the two stimuli which are being compared are on the other side of the limit (i.e. are both equal, or nearly marginal), than they differ little from each other, no matter
How, different the absolute values of their intensities, may be, of a stimulus, 
remains, however, below the limit of 
its consequence of fatigue becomes minute 
or nearly so, whilst the other one compound 
therein is still in the maximal area, 
thus the effects of the two excitations are 
pronouncedly different, although their 
intensities, estimated according to their 
absolute value, may possibly show only 
small differences. As speculated upon 
the cause of this rare occurrence, it occurred 
to me, that the frequency of the stimulation 
exercise, a great influence on the latent 
period, that perhaps the frequency might 
very well be related to the intensity. The vibrating staff 
which produced the frequent interruptions 
(22 and 30 per second in the foregoing approximate 
series) gave 11 to 15 closures per quit—a quite 
many openings per second. In that the opening 
with thin currents far more powerfully than 
the closing ones, so the former will beactive 
with a difference between the distance of the 
primary from the secondary spinae, whilst 
the latter will be quite without effect. 
If the approximation of the spinae 
however, i.e., carrier so far that the closures 
also become adequate stimuli, then the 
frequency of the effective stimulation 
will be doubled.
So that this view I arranged the inter-
ruptor so that instead of making t-
opening the primary circuit, it closed
opened a short secondary circuit (anal-
lytic arrangement of Helmholtz on the
inductorium) Although I did not
succeed in making both shocks comple-
equal, still the difference between the two
were very greatly diminished. This arrange-
ment did not permit of very rapid vibra-
tion of the staff.

The following Curve (Fig. 3) gives the
results of an experiment obtained in this
way.

[Graph Image]

Curve of latent stimulation from a reflex preparation of
the frog. One foot has been stimulated by alternating currents
whose the directions had attained, using coils of
intensity. The stimulus strength of the varied
between between 150 and E of the graduated
inductor—machine. It is noted when the change
has made. After each stimulus there was
a period of rest of 1 min. The units in the
ordinate indicate seconds of latent time,
the abscissa—units period of stimulation.
The curve is constructed in this way that each point on the abscissa corresponds to the duration of each period of stimulation together with the time for rest (1 minute), the corresponding latent periods are drawn as ordinates, each of which are indicated in seconds upon the ordinate placed at the beginning of the curve. The connecting lines between the end-points of the ordinates gives the curve of latent stimulation. The vertical lines, which reach from the broken ends of the latent period curve to the upper limiting line, show that that stimulus acting at that time did not produce any reflex movement, i.e. that the latent period can here be marked as indefinitely great.

This curve shows that the duration of latent stimulation in a fresh reflex preparation is not essentially changed when the strength of the stimulus is increased 125E, 112E +100E act after a duration of the stimulus of nearly equal length, whilst after the latent period of stimulation with unchanged strength of stimulus the latent period gradually lengthened 4-2\scriptsize{1/4} But if also remained at this height even with 80E. Then after diminution of the intensity by 20E, the latent period became
considerably. Soon however becomes quite ineffective (Latent period). The limit reaches about 80 E after short duration of stimulation, which does not essentially increase with 70 E, whilst 60 E remain without effect. With 80 E the latent time again occurs, when it has formerly broken off with 70 E. Now becomes 2. 90 E act at first with relatively short latent time, then after a moderate period. Lastly, the excitability seems to increase, but 80 E remain without effect. So do 90 E. 100 E can only produce effect for a few periods of stimulation. Under the influence of 100 E, we find certain had no deleterious effect; the latent times increase rapidly to 2. 150 E produce still after moderate duration. After action, the preparation is deserted, the nerve restored with 1000 E.

This result confirmed of course by many series of experiments shows, that the duration of the latent stimulation, as we can always so essentially depend on the intensity of the stimulation, as has formerly supposed. When moderate stimuli with diminishing entirely become very minimal, the latent periods become considerably longer and can again be diminished by strong stimulation. We see however at the same time that stronger (sub-maximal) stimuli are not able to compensate the
The weakening influence of the resulting actions, as in nerve-muscle preparations. The capability of energising, shown by the reflex frog in the rapidity of its reaction, apart from the nature of the contractions, diminishes in a much more irregular manner than in a muscle; its curve is first to be obtained very flat by long periods of rest as with muscle, but it comes always steeper toward the end, it breaks (as formerly shown) frequently quite suddenly.

The length of such a fatigue curve, the increase or rise of its individual parts is however, even at the same time of the year (winter) are subject to very large individual variations. Thus a very irritable preparation at the beginning of the experiment reacts to stimuli of 5 units, after 5 sec. latent-stimulation, but after it has endured 75 periods of stimulation (in the course of 12 hours) induction currents of 8 to 15 E. delting at 1/2" interval suffice to produce reflex movements after the latent-stimulation. Such differences in character are shown also by reflex preparations with regard to their susceptibility to currents of different directions. Whilst in some frog descending currents (from the foot toward the leg) of descending waves were completely alike, in others the descending direction of the closing induction shock was more effective than the ascending one, whilst in others vice
this relation was reversed. So, when of contrac-
tion, first for reflex preparation, just as there is none
for the frog muscle stimulated with induction
Wissensch. in Berlin 1870, p. 140). In the former
the inconstancy however is greater, in as far as
the reaction varies in the same individual in
the different degrees of fatigue. In Fig. 4, the
results of an experiment are shown, where the
effects of different-direted currents in
the preparation during rest and activity. In order that
in every period of stimulation only equal similar
induction shocks would be obtained, for this I
arranged the interruptor so that the anchor
(like Rogers hammer for Pflügers bleeding)
(E. Pflüger, Untersuchungen über die Phys. d.
Elektr. Berlin, 1873, p. 120). As soon as the
magnet had attracted it, lowered a string
of copper wire into vessel will be rh. were
connected with the poles of the secondary
spiral of the induction coil. Thus the opening
shocks were conducted away from the
preparation. - This arrangement at
least properly does not permit of any very
rapid vibration of the anchor. The equal
directed closing induction shocks were
reversed after each series of stimulation
so that - the fact was alternately trained
by ascending (V) and descending (N) current.
In the next period, they that you will
at first attend only to the upper curve, the lower one will be considered later.

At the beginning of the upper curve we see that the latent-periods are essentially independent of the direction of the current. From the 8th period of stimulation onward the currents in the ascending (1) direction begin to distinguish themselves by short periods of latent-stimulation, whilst the descending (2) induction-shocks require a little longer time of stimulation than formerly, one (7th period) even to 24" to produce strong reflex actions.

Fig. 4.

Closing induction shock, of 20 E intensity in 1/2" internal. Stimulate the reflex preparation 55 stimulations each other after pause of 73 mins. Alternating ascending and descending. The marks, in the direction of the current, alternate radical period of stimulation. The ordinates marks, each 5" latent-stimulation. The upper curve radical, the time of string reflex contraction.
The longer latent period for the descending induction - shock-formation may be referred to the 10th law of contraction formulated by Rosenau (10) that: 

"Die Reihenzeit für die neuen Reaktionen hängt von der Größe der Folger für die Nähröse."

After a longer pause (13 minutes) whilst the pathway of the secondary erosion was being cleared, very peculiar differences in the action of the currents in both directions set in, so that after four periods the latter of the latent curve become very large. It appears that the latent period only measured for currents in one direction till over 51 "latent" stimuli, a peculiarity analogous to that cited in Table 1. There he remarks that the latent period increase only a little with the fatigue for strong stimulation, but increase considerably for weak stimuli, so that the quotients of the latent periods always considerably exceed the reciprocal proportion of the time of stimulation. - The latter periods of the type 

We. are not given in the graphic representation of the results also point to remarkable change in the irritability. The curve contrary to the direction of the action, of the ascending + descending currents disappear, just as was the case at the beginning of the presentation. Later, the latent times increased, the fatigue for both of the directions of the current with currents of high intensity contraction, with very short latent-period can however be again obtained.

In Histone, the individual shocks follow each other...
at intervals of 1/2".

The time of latent stimulation, act, reach the considerable values of 1 minute or more, and are infrequent. Only in these cases, therefore, do we observe great change in the latent time, with change of the intensity of the stimulus.

It has to be expected that the duration of the latent period would be essentially influenced by the intensity of the stimulation. The three tables, n.b., serve as samples of the action of varying strength of stimulus, with exaggerated differences of observing the influence of the varying frequency of stimulation.

In Table I (P. 9a.) in the last line, wherein the intervals of stimulating the latent time 2.0 and 0.5 are noted, n.b., corresponds to the strength of current 150 milli-amp., whilst in the next series of stimulation of equal intensity with an interval of 3/5 or 0.625 lapses before a contraction occurs. Hence pronounced, however, is the difference between the two neighbouring latent-value 2.0" and 0.5.

In both cases the induction shock was of equal intensity (10E); but in the first case the latent period of stimulation was 1/2"; in the second 1/8".

In Table III (P. 17.) there are smaller change in the interval of stimulation (11 + 1/5). But here the time of the latent period clearly varies with change in the interval.

1) 11 stimuli (100E) per sec. act after 1/2" latent + 0.7"

2) 15 " (150E) ... 0.9"
3) 11 stimuli (150 E) per sec. act after 1.0° lat. 1°15
      "  "  "  "  "  "  "  "  "  0.8°  

A glance at this table might be apt to lead us to the hypothesis that a certain number of stimuli of a certain intensity were necessary at each stage of the stability of the preparation in order to produce a reflex action.

In the first parallel cases 17, 7, 13, 0 stimuli respectively were applied to the limbs before it was raised; in the second pair 10, 5 and 9 shocks were effective. In the third pair the limbs reacted at 11° 4 12° 5 modulating shocks. Such an assumption, however, is very true in seldom cases.

In order to have deviation toward both sides.

A tabular view of some numbers of units of the nerve necessary to produce reflex action in neighboring period of stimulation of equal intensity but ranging interval will not only serve to elucidate the just mentioned hypothesis, but also to give other useful indications.

The following table is taken from variable tests. Here all conditions of the HPS were equated. Each of the running members in the table indicate a series of the HPS. Several pairs of the HPS carry similar figures, with different letters.
This table shows the abundance of the collected elements.

The following table contains data on the abundance of the elements in different samples.

<table>
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<tr>
<th>Sample</th>
<th>Element A</th>
<th>Element B</th>
<th>Element C</th>
<th>Element D</th>
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<td>20</td>
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<td>2</td>
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<tr>
<td>4</td>
<td>25</td>
<td>35</td>
<td>45</td>
<td>55</td>
</tr>
</tbody>
</table>

Note: The data is corrected for background radiation and rounded to the nearest integer.
A cursory glance at the foregoing table shows that in the same preparation, in the same stage of the testability, with unaltered intensity of stimulus, the shorter latent period belongs to the smaller intervals of stimulation.

At the same time it is to be observed that it is quite unfair to compare the results of several series of tests with each other, for with the same interval of stimulation there are very varying latent periods: e.g. with $\frac{1}{8}$ interval, variations between $0.5''$ to $5''$ latent period; with $\frac{1}{7}$ interval, latent stimulation from $1''$ to $30''$ on.

The instability of the different preparations is so various, that for each of the stimulating currents, one must judge another entirely. Of course the cited units of time do not serve as absolute measures, because the glass elements employed for the production of the currents were not filled each time with pure acid. During the same $\phi E$ however, the combination remained obviously constant.

Through the individual experimental differences, however, it is like remarked that frequent stimuli (at about $\frac{1}{8}$ interval), even under unfavorable circumstances, (altered and unstable at weak though of current) do not reach the long latency belonging to them with seldom stimulus ($\frac{1}{2}$ to $2''$ interval).

The greater the difference of the corresponding interval of stimulation, the greater also is generally the difference in the times of latent stimulation.
The interval-difference $\frac{4}{5} - \frac{3}{5} = 0.07$ corresponds to 1.89" as the difference of the time of latent friction from the cited data. If the interval-difference $\frac{4}{5} - \frac{5}{5} = 0.125$ coincides with the mean latently-value of 4.07", the difference of the interval $\frac{4}{5} - \frac{3}{5} = 0.25"$ then belongs the mean of latency different 12,".

The more pairs of periods with the interval-difference $\frac{3}{5} - \frac{4}{5} = 0.2$ cannot be used for the estimation of the mean value, because the two last groups correspond to the stages of greater fatigue.

For the interval difference 0.5, the corresponding mean value of the difference in the latent period is 23.3". When he however include the results of the jumps 196 + 22 = 9.0 + 3.5", then he arrived at the mean value 9.0.1. It is of course probable that a slight value belongs to the peak difference 0.5, according as it comes from 1 - $\frac{3}{5}$ or from $\frac{3}{5} - 1$, or from $2 - \frac{3}{5}$.

The main thing - the shocks following each other at intervals of 2" or 3" must for most props be chosen very strongly and be often repeated to produce an effect, whilst the shocks that follow each other at intervals of 1" without their having very great intervals, are sufficient to produce the same action in many preparations. In some however (where $\frac{3}{5}$" interval is quite unaffected) first after frequent repetition.

Of interest is the difference of frictional latency, when we regard the relations of the same, then we find that this is most easily increased in the number of beats necessary for stimulation, which are given in the 5th column.
From these numbers it is obvious that we cannot assume that in order to produce a reflex act, with
exchanged abilities of the limbs, a certain amount
of Nervium is necessary, which with varying specific
frequency intense shocks require a corresponding number
of shocks. The bracketed shocks of pairs 4th to 14th considered
from each other. Only in these pairs, appearing
by accident, are their equal values (1935, 3a, 3k).
In 51 for the most cases large number of beats belong
to the great intervals i.e. the duration of latent-
Formation with all other Nervium is well-mg absolutely
longer than with frequent ones, but none than is necessary
to form of the completion of one equal Nervium of
Nervium. In subsequent number of beats of the
seldom Nervium must exceed a multiple three
of the frequent ones before the hint is raised. This
phenomenon has a considerable analogy to the
results of Mr. Bate's investigations (p. 7) who shows
that the time of latent-action increase more rapid
than the strength of the stimulating acid diminished.
Only the two first-profits cited in the table deviate
from the relaim of the others. Relatively very many
Nervium of short intervals are applied to the limbs
before it is raised. In 3i cases
The cause of this peculiar phenomenon with
the aid of completely his experimental methods, have
not found time, etc.
Further, from the same table, it is to be noted
how with great-intensity of stimulation the time
of latency diminish when somewhat
Fatigue acts as was shown already (p. 23 Fig. 3) in an opposite manner. In the 3rd group, 
while the same intensity of stimulus as the 2nd—i.e. the latency for 2 is indeed smaller; but its degree of the reflex action was at the same time in this case a very low one. I shall return to the relation between the degree of contraction and the latency-time. The long training influence of fatigue in the latency can be compensated by increasing the stimulus, but this is not valid in an equal degree for all intervals. Whilst with medium intervals the fatigue can be overcompensated (p. 6. 8a, b) the same no longer be done with the larger ones (12a, b, c.). But in the duration of the latent stimulation, some reach a very high degree. The increase of the latency with stimulation of different intervals will be made plain by the following curve. (Fig. 5) constructed from the data of a series of 44/5.

This series of 44/5 shows how the post-sensory 
reacts equally rapidly to stimuli of laterally different 
intensities (20 E. 412 E.) and different intervals (2 or 12). 

The 4th of the two first contractions is somewhat peaker than that of the next following, which reach its peak. 

In the 6th period a reflex act develops. It is obtained under the same external conditions, with an interval of 2 however after 2. The process into be repeated, interval 2 requires only the fifth part of the intensity of stimulation of the interval of 2.

In the 12th period of the 4th. The reflex develops 
slowly as stimulus has somewhat-contradictory but in the following periods the latency increased significantly.
Beuse of the times of latent-stimulation. Reflexes performed with increasing currents of varying intensity (12-20 E) at varying intervals (155-205). The units of the Abscissae indicate the periods of the light, 10. Each interval in the under notated paces, of 1 to 10 minutes, each unit of the ordinate correspond to 1 free latency. The strength of each reflex is indicated by the figures I, II, III etc. already indicated. The C indicate the time when the continuity of similar limits contracts before reflex indications as finished. Where no figures otherwise is added the last noted number is utilized.
became i.e. the stimulus 12 E 2/3 was unable in spite of modification for several minutes, to produce a reflex action. In the mean time the frequent stimuli of equal intensity remained still moderate, the duration of their latency remained small. For the second half of the experimental series the stimuli 18 E to 20 E must be employed 20 E 2/3 remain nearly as long irrespective as 15 E 2/3. While the frequency,
with the same intensity of current were compared, the superiority of the smaller ones is shown in a very striking manner. The series of shocks following
each other at intervals of 2/3 acquire nearly ten
times longer stimulation before a reflex action
appears, than those of double the frequency. In
the first case five times more stimuli were applied
to the nerve than in the latter. It is to be observed
that the same time, that the late reflex actions
do not by any means require to be weaker than
those occurring early. If it occurs a time after
the presumptive latent time, then the must look
to the magnitude of the stimulus employed, or if other
currents have been employed, death will some
place. In passing I beg here to remark the
pointing out the beginning of the curve, where it
begins to miss-dots like the course, the increase of
the latency for seldom stimulus does not become
directed, but a 'real' contraction, & instead of the
which would be expected (line one (I or III)) occurs, the
definite one occurring several seconds later.
Such sub-maximal reflex actions, I will call
"preliminary" in opposition to the "final contrac-
tion." This phenomenon is repeated in the nerve (2") after
the 3rd the preliminary contraction occurs somewhat
later. In the 4th to the 6th the mark 0 occurs regularly: in
the 7th to the 5th with the end of the first horizontal
part of the curve. In the 6th to the 9th the point of
preliminary discharge is complete, gradually
final one is obtained. Indications of
relations are also to be found in the second
part of the same curve, especially in the part that
belong to the with frequent stimula-

The best figure 6) presents without an account
the "relative distribution of the" preliminary reflex
where indication 0 will occur later in connection
with similar phenomena. This curve is nothing
being communicated on account of the seemingly
large variation in the height, because it shows
the temporary modification of the. reliability of a
highly fatigued preparation, such as have
considered in Table III.

The frog Ms. yielded this curve; generally
(Dig 6 p. 37a) gave equal in the first two periods
stimuli of interval, 1/2 "4," obvious difference in
the latency. The initial part of the above curve
Ms. var. exceeds by 11 equally effective periods
stimulation shows that the latency of the
stimuli (1/2 "Int.) are longer than those of
frequent (1/2 "Internal," even when the intensity
of the first (20E) somewhat exceed that of
The time of latent stimulation: When preparing a stimulating voltage, the threshold is found by taking the time for a reaction of the subject to occur. The figure shows the results of such a test.

Preparation: stimulating voltage (600 V).

Threshold: 7 to 10 V.

Results: each subject was tested 10 times. The median reaction time was recorded.
of the latter (18 E.). On attempting to lengthen
the latency of frequent stimuli by diminishing
the interval of the current (to 16 E.) the reflex
did not occur. Alternate stimulation with
20 E ½" int. + 18 E ½" produced latent periods
graphic representation are given by the flat top
figure of curve. Thus upon a preliminary case
of occurs at the time when the final one is
excited. This is postponed till 45" after the
beginning of the period of stimulation. The next
definite point of contraction for 20 E ½" int. starts
at the right place. The curve now remains
for the period, although in the second instead
the stimuli 20 E only 18 E were employed. The frog appear
have become more suitable. Nevertheless the call
for 20 E ½" int. only gain reaches the former value
after a preliminary reflex has produced. The
18 E ½" int. was kept constant, whether it were
its effect 20 E ½" int. as was done by 20 E ½" int.
relation to 18 E ½" int. The expectation was
fulfilled! at the corresponding time no pen
contraction occurred, but there was a weak pen
disturbance successively by the others, after 58" of
plast after 109" of latent stimulation and
strong discharge. In the following period
stimulation the test animal has followed
that the last reflex on stimulation by
½" int. follow only 5" later than the ref
first frequent succession of current (18 E).
Soon however the difference in the last
period of the reflex. The frequent stimulus became peal, but the former increased by strides, then varying would within mere bounds. This relative change in the of curve m. is well-arranged. The reciprocal influence of stimulus X S E could no longer produce a reflex,
be supplanted by the intensity 20 E m. also went for a long time. In the meantime the time latent stimulation for the frequent stimulus remained unchanged at relatively low values 3" - 4". As the preparation became very fatigued the stimulating voltage also summed themselves, up, sometimes to 40", to a visible contraction.

While the two former series described (Fig.
sequence of 4 per second for the comparison of the effecti
seldom to frequent stimuli presented absolutely lati
city, the following 4 per second (Fig. 7) presents
4 per second series at m. the seldom stimulus (m) 3
at the maximum on 45 seconds to produce
reflex, while on the contrary the frequent ones (g) re
form after 0.5 seconds, in the series of 4 per secon
d the reflex were much more than 2 to 3" to produce the same curren.
In the first place the cause of this relationship be
the relatively high frequency of both stimuli but
the individual difference in titubility and ab
been shown by the specific 4 per second reflex on the
muscle. Compare A. Kramer, Anat. der sere
Abstract to Leipzig, 1871, p. 204.) Since the
4 per second series where with 4" interval this
intensity of current cutaneous reflex necessary to produce a reflex action, tal
others (June 1873) in which 0.25-0.5" (i.e., 10-20 shocks) were insufficient to produce the current-brush. 
The intensity of the current employed being much 
higher (27 E + 200 E.), in the mean however the 
latent times which correspond to the interval of stimuli 
"remain within the bounds 2" + 10" + those of the de 
written 0.5" + 4." 

In order that the smaller variations in the latent period 
may be made plain, in the construction of the following 
curve, I have given the ordinates 3 times, smaller 
value (true time) than in the former curves, so that 
occupy the space between two lines.

---

![Graph](image)

---

Curve of the line of latent stimulation. Reflux preparation 
stimulated with induction currents whose velocity remained 
constant in each hank of the series, i.e., 95 E. (from 30 E. to 35 E.) 
the interval (5" + 8") alternate. The units of the abscissa are 
seconds, those of the ordinates, seconds. The degree of current 
intensity is indicated by the marks, I, II, III. Where these are used 
it is of the normal final strength (III).

In the small preparation we find against the zero 
of the variations in the latency with rollover success 
of stimuli as in expressed in the previous curves.

The latency of the fresh preparation nerves, with 
also a change in the interval of stimulation.
Suddenly however the times of latent stimulation rise to a high value for seldom shocks, while for frequent ones the small latent times remain. The third point of the great teeth remains much deeper than the two foregoing ones, but the reflex is characterized as weak, and that the new stimulation with interval of more reflexes produced. This shows that the previous reflex action was only a preliminary one, but the final one could not take place. Then a somewhat lengthened pause the stimulus 30 E ½ in. did maintain the action. The current of 35 lacs however after a longer time produce a result after, roughly, for long latency.

In this series of 415 only the first reflex is act but occurs in noticed. The stimulus was interrupted as soon as the subject had responded to it. Preliminary reflexes are always therefore noted as final ones. Thus is partly explained the relatively large variations in the latency when one to keep count the degree of contraction. I shall look more deeply into this point. Up to this time we have considered the changes when the duration of the latent phase with the intensity of the testing current is changed, but when the interval varies. One occasionally has the result of effects of simultaneous change in the amount of the two variables.
The next curve (Fig. 8) shows how the reflex times change when stimulating, tempo, strength of stimulus, and rate of stimulation are changed in the opposite directions. As we have seen from another series of experiments (245) that a fresh preparation can resist tolerably rapid changes of different stimuli, so I have begun the curve here represented, where the differing interval of stimulation in the graph permits tolerable variations in the latency.

![Fig. 8](image_url)

Curve of the times of latent stimulation, reflexes are shown with induction currents. While intensity here is kept equal, whilst the interval of stimulation varies. But later, it was varied in an opposite direction. Then these alternations were the intervals, with constant strength of stimulus! Lastly both variable. The arrival mark periods of stimulation separate by pauses of 3 minutes from each other. It indicates, rest for 10 minutes. Each unit of the ordinates corresponds to 2 seconds. The figures I, II, III indicate the degree of contraction.
The absolute values of the latent times are always has kept small, remaining within the limits 1" to 8". Only in a single case the stimulus remained latent for 16 secs. Here however he had to do with totally frequent shocks. Now we must discuss the relation of the small amount of current in the already known picture. The first looked at part of the curve presents again the varying amount of latency with equal strength of stimulus, with the intervals (1/8 + 1/8) during three periods, whereas the same interval was employed the latent time remained unchanged. The latency however could be kept at the same level and a diminishment of current went with smaller interval/induction shocks of 20 E at an interval of 1/8 remaining equal to current of 15 E with the temps 1/8. Upon again employing the strength of stimulus 15E the different effects of the varied frequency became apparent. Now however 15E 1/8 still seemed to have an effect - that completely, after having forced a neural discharge from the reflex center. Whilst in the reflexes where presence of 15E 1/8 still no change was to be observed within the degree of latency. The compensation between the frequency and the intensity of the stimulus can be reached in higher limits, the latent time but suddenly the susceptibility and frequency instead of 8" 15E 1/8 requires 16 seconds found.
real action, at 20 E/" int. appears of
at 5" for a trace of a reflex. Afterward
of stimuli of 20 E of 50 E even greater
produce more involvement.

From this series of tests, it is obvious
it is possible to compensate diverging
of stimuli of different frequency times.
the cannot judge any indication, how
the component variables must be chosen
that constant latency times may result, as
have seen (in Table III). A series differ
or proportion of stimuli, corresponds to the
difference, or proportion of latency. The
of different frequency stimuli, the latency
times with disappearing excitability; in
stimuli are quite different proportions, with the
stimuli and rapidly more in strides than with
stimuli. The increase of stimuli per se
in a fresh preparation is sufficient to give
distinct intervals, the power of peak
of stimuli are not sufficient with the
fatigued preparation, a circumstance that
appears clearly in Fig. 5.etc., also to be
noticed in Fig. 6.

Of course with varying moderate doses
of stimuli, one cannot obtain constant times
constant size, by making the stimuli in
moderately, thus, but then there also
occurs the minimum of latency. In
a case of course nothing is to be lea.
regarding the relation of the stimulus of force to the strength of the motor. The following is deduced from our tests.

By variation of the intensity of the individual shocks, the latent time can only be changed within narrow limits, as the latency is determined by the interval of stimulation. Therefore, by means of examining large variations in the duration of the latent stimulus, small differences in the latency caused by changes in the duration of the latent stimulus can be compensated by changes in the intensity of the current, but not great differences. However, further the time of latency cannot be varied indefinitely by changes in the current intensity. The intensity of the current, which are sufficient for frequent stimuli, do not remain for seldom ones. This may be seen from the curve of Fig. 527. The more seldom (at first very active intensity) soon become complete, ineffective, still not maximal latency having previously been obtained. We must think the intensity of the current to produce effects from the seldom shocks. The more the interval of stimulation to increase the more powerful shocks of currents are necessary to produce reflexes.
Table V

shows how the time of latent stimulation increases with the interval of stimulation, even when stimuli from adjacent strong currents produce an effect. The latencies are taken from the table.

<table>
<thead>
<tr>
<th>Period of Stimulation</th>
<th>Interval of Stimulation, Secs.</th>
<th>Strength of Stimulation,Volts</th>
<th>Latent Time, Secs.</th>
<th>Degree of Endurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 Minutes</td>
<td>3</td>
<td>0.0</td>
<td>0.5</td>
<td>II</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>0.2</td>
<td>2.5</td>
<td>I</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>0.4</td>
<td>5.0</td>
<td>II</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>0.4</td>
<td>3</td>
<td>III</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.4</td>
<td>4</td>
<td>III</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>0.4</td>
<td>5</td>
<td>III</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>0.5</td>
<td>6</td>
<td>III</td>
</tr>
<tr>
<td>0.5</td>
<td>3</td>
<td>0.6</td>
<td>7</td>
<td>III</td>
</tr>
<tr>
<td>0.3</td>
<td>3</td>
<td>0.7</td>
<td>8</td>
<td>III</td>
</tr>
</tbody>
</table>

In this table the bracketed numbers indicate the latent-time of reflex contraction following each other ('Preliminary' and 'main') in a series of stimulation.

It is worthy of note that here the latent-time for small intervals (0.25") which are at first irregular, and become uncommon long after the period of stimulation large intervals, but similar intervals of stimulation.
first diminished by relatively strong currents, to the ordinary amount, whilst the hair generally show their state of greatest latency, they generally remain at a lower level.

The true duration of the stimuli are shorter, the earlier they become active in the stages of fatigue. Induction shocks (closing + opening) following each at an interval of 2.5" have an even shorter active period, excepting rare times, when displaying very high strength of stimuli with great persistence. In the case of the latent stimulation, as is shown in the following Table 7, very short, as pharyngeal shocks were applied to the foot immediately at the beginning of the fight. Soon however, the susceptibility is lost for the seldom stimuli; then gradually for the always same frequent and with almost dead preparations. Also ordinary induction shocks had no long latent times. Suddenly, after a double period of rest (2") had rendered possible a contraction with short latency to stimuli of internal 0.5", the susceptibility was completely lost. Finally, even to the all other times, insensible pincushion.
Table II

Shows how stimuli applied to the brain, after an initial effective application, fail to produce a response when the intensity of the stimulus is reduced. This is illustrated by the data in Table II.

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Intensity (mV)</th>
<th>Frequency (Hz)</th>
<th>Duration (sec)</th>
<th>Initial</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>2.5</td>
<td>1000</td>
<td></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.3</td>
<td>1000</td>
<td></td>
<td>8.8</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.0</td>
<td>1000</td>
<td></td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2.0</td>
<td>1000</td>
<td></td>
<td>8.8</td>
<td></td>
</tr>
</tbody>
</table>

Note: The data indicates that after an initial effective application, stimuli of reduced intensity do not produce a response.
In another case where the shock of natural 
100 E had been applied without effect for 
30 minutes to the limb of a fresh preparation, 
without effect, 1000 E produced after 40 
seconds a weak reflex, then with the 
direction of the current reversed a weak 
contraction after 17.15" of latency. Hereafter, 
the interval 2.0" itself was almost completely 
without effect, it required stimuli following 
each other every second to produce reflexes 
even after that latency. After several 
series of stimulation shocks of intervals 
0.5" red no more to be touched than 
the preparation still.

Strong stimuli therefore act rapidly, 
acting even without producing any 
detectable reflex. We will soon see that 
short maximal shocks, also i.e. those 
with moderate interval of stimulation 
just sufficient to produce a reflex with 
greater intervals, would then with the 
appropriate pronounced? These, here an essential difference from the condition 
of the transversely stripped muscles, in 1.2.
Kronecker remarked the peculiarity of this, 
"Zwei schwächere Reize, denn die kemei 
erheblicherer Reiz nicht haben, nicht Ernährung 
mit so maximal Reize kann auch von menschli-
ische Wirkung für dass auch. In der Tat, 
mit den 
mit Wirkung verschieden Reizen behandelte Muskeln
Note: The aberration observed by Draper (P. L. 445, 1871, p. 264) is only apparently so. The closing induction shocks, which here regarded as special value with the corresponding opening of the No. Here will be explained, as I am known by this, that they became more effective than the opening shocks, even at the beginning showed small difference in the heights of the pair of closing opening of the corresponding-induction shocks given in Fig. 22(a) Plate I. The relating some different from the central designated by Drucker (L. C. 1866, P. 260, Fig. 30) as maximal and sub-maximal.
Sich fast wie Ein Fährnand verhältnis.

(.Ab. aus Dr Phys. Anstalt in Leipzig.

(71. p. 264.)

...he Theorie, der Halt Successee Mühl
produce the positive result in the preparation
by to produce movement of to the finish life.
This disagree influence seems integer
in the highest degree on to the start
because Mühl's movement on the contrary
as we have seen is better assisted by re-
pletion of the shock, also by strengthening
them. With Mühl's movement on the contrary
energy Mühl to be effective at all, the
influence influence in therefore incompar-
ably just frequent successes of shock.

How can he conceive this summation
of movements?

By observation of the already cited "Färnand
offense" believe we shall be able to gain
much important information.

Turk in his already cited paper remarks,
that "Sehr häufig erfolgte eine kräftige
Stoß- und Klangbeugung der in den zwei
getreue den Sphären (der Broche) nicht löst,
sondern so selten sind, erst geringe, langsame
Bewegungen voraus" Es wurden dafür auch
je halb 1/2 - 3/4 Sekunden Laufzeit an der Normalen
12-17 Sekunden Laufzeit an der Normals
7-12 an der hyperästhetischen.

(2) L. C. Depard. Lös. p. 3.
Sanders-Ernst Mende aus d. Phys. Institut in Leipzig 1867 p. 29. in a speciesscripta dienim "die Verwahrung desselben Bewegung bei Ausräumung (chemischer) Reizung". He finds an appreciable pause always elapsed between the first and second appearance of the second muscular movement, the pause being the shorter the greater the rectitude. "Dieser, abnehmende Verschwinden und Erscheinen der Bewegung zeigt an, dass der Reiz, obwohl er entweder beständig vorhanden, dennoch nur periodisch seine auslösende Wirkung ausübt. Neubauer, Hall, Starre, Haner, Marullas, beachten Stimuli hier applicirt sofort, nach einer und derselben, folgenden die letzte Stimulux mehr energischer, als dass, welche ausschliesslich ersten erfolgte. So the most probable explanation of this, he holds "daß die vom Ersten Reiz der Schmerz gemachten Kräfte, bei der darauf folgenden Bewegung nur teilweise ausgelöst wurden, während der restierend Theil sich die der zwei und letzte bewegung, welche durch den Zweiten Reiz desponibel wurden."

An analogos phenomenon was observed by Eduard Weber (in : Machebeugung Physiologie, Band 2, Teil 1, 1846 p. 19) as he cut the alternating current from an electro-magnetic apparatus through the limbs.
habo & Nüttenagel. (Zur Lehre vom
eklinischen Krämpf. Virch. Arch. 13. 49,
p.276.)
Mr. has only connected to the brink by the ischiadicus. Weber observed (as is indicated in the beginning of this paper) that a considerable time elapsed before the movement followed, "dass ferner, wie bekannt, die Einwirkung des Rotationapparates ganz abrupt, fortlaufende, die Muskeln bewegungen rohre, führte. Zwischen solch fließen, und Schmerzen kamen, als ob das Gehirn, wirklich Ausströmungen machte, dass stetig macher und auch immer dieselben Muskeln in Bewegung gerieten.

Shillers peculiarities were observed by tetanum in electric stimulation of the central end of the ischiadicus. Just heat stimulation with tetanum current of the induction machine, he observed at the beginning of the stimulation, a single transient movement of the anterior thigh, or following this, still a series of quivering, contraction, lasting for several seconds, then rest. Moderately strong stimulation causes at once strong movement in both anterior thighs, but then assumes a tetanic character, to make woman in a proceeding as in the former case for absolute rest. After the tetanic of the stimulation is continued after the elapse of sometime (sometimes 1-2 minutes) a tetanic wave is observed to pass over the back of the leg, whispering...
begin in the femoral muscle of the hind leg, is propagated from here to the adductor muscle of the arm. It is propagated in the form of a string containing tetanus. Later there follow small coordinate movements. Bei stärker Reizung wird die erste Bewegung pause übersehen, Achat der, anstatt eines sichtbaren Hubs, ursacht unbedeutende Bewegung in der Tetanustätte mit nachfolgender Pause. Von einem Sekunden oder einer sofortigen Auftreten der zweiten Bewegungsphase in Form eines tetanischen Hubes der Tetanustätte mit nachfolgender Pause. Setchenow explains the first attack as an "inhibitory phenomenon" produced by the string of muscles, and how when the strings of the nerve is interrupted at the beginning period of rest, one always attains an after-effect of (sometimes very strong) tetanic contraction of the arms.

Setchenow made progress in the analysis of the process of summation of excitation by the central end of the ischiadicus with single electrical shocks. He says (C. p. 11) "unterbricht man die Ischiadicusfascialisstromkreise und schwach ersichtlich, als ob Schließung und Öffnung desselben Impulses die Wirkung vermehre, so überrascht ihre Frequenz wie 60 mal in 1 Min. so tritt nach einer Unterbrechung die erste Zuckung noch schwächer, um in einer beschränkten Anzahl von Mustern
Ein, die zweite dritte u. s. w. werden immer flächer und ausgebreitet, bis endlich eine Bewegung der ganzen & dementt. Für Hande könnt aber auch getzt nicht wundermoch oft eine jede Vormessungswachung durch eine Zuckung inner in der Bewegung begonnen, dementt. beantwortet. In einer der abe abe dten, papers und the old round nine such result, regarding the relations of time by Mr. the reflex, produced at different parts of a period of stimulation, hand to each other.

Tabelle II in this paper gives some rules Mr. Thors. not moderate frequency of stimulus (s) a moderate, rapid rise are of the x-axis, and of the preliminary as well as of the final reflexes. A series of these is presented in Fig. 1, where the preliminary reflex has occurred in every period of stimulation. The characteristic curve of these times of latency Mr. I have and handled of. While this curve was first introduced, I have again introduced.
Close-up indications checks of 20 000 m/s indicate the preservation. The periods of stimulation follow each other after 15 seconds, alternating in a descending (↓) and ascending (↑) direction of the current. The line in the absence indicates periods of stimulation, three of the ordinates, each 5000 m/s, of latent stimulation. The lower curve indicates the latency of preliminary peak reflected. The upper indicates the point of final (strong) stimulation.

The course of the lower curve denotes that of the upper one in a marked manner. Whilst the latter is characteristic by its large beats that - the latent - lines for the descending currents rapidly increase to very great values, the balance of the preliminary peaks remain within narrow limits (5-8 km). Although here a less action of the
of the descending current is also stronger. Further the preliminary reflexes, in the case, had a peculiar form. They were all rapid and small, consisting only of a twitch and continued elevation of the foot, which gradually increases, till they added weak movements of the knee; till suddenly the flexors of the foot, leg, and thigh became strongly contracted after which the suspension of stimulations, punctuated by the quick and weak twitching to its position of rest. In many of the cases where the stimulations had to last very long before it produced a final contraction, the neck in its contraction approached itself, following a long irregular passage (when capillary is not indicated in Fig 1) between the curve drawn by the flake for the foot's foot again became more and more the shape. It was observed that one of the most supported by &c. Cyan. (cf. Hürzler. Arch. 1874 p. 545) on several subjects, in mounting the chin with cold or moderate shocks, severe pain, also whilst tetanic shocks were applied to the limbs. As a rule however the preliminary reflexes remained separated from each other from the definite one. Their course is sometimes fast, generally however steeply ascending and descending. According to the forcing course there are two essentially different facts: 1) in fast, regular or irregular sunde...
mostly of this sort. Note all preliminary contractions are small degrees; or that at later ones are larger than the first ones, 2) after short or large latency in normals, i.e. are isochronous with all stimuli, or when there are preequalstings with the stronger. The preliminary contractions are almost always of the 1st degree. The following Fig. 4 illustrates Fig. 4 plus an example of the first sort.

Fig. 4.

The limits of a reflex for preparation in readiness is usually given by the writing lever, stimulated with alternating induction currents of 160 V at intervals of 1/16 the elevation being written on the lower line of the index paper. The middle line bar is a second accessory key is instead upward as soon as the stimulus is applied to the limits. It downward they cease. Seconds are marked on the lower line.

The first small elevation of the pole begins after 3.5" after the beginning of the stimulation, after this, one a little stronger after 6", then after 25 individual heart beats of 9" to 20"
Hastily after 48" latency a stringeration of the whole limb (degree of contraction III). After a short pause this stringerati, replaced by frequent stimuli, 4" interval, of the same degree after 4" latency, lost a high contraction but even with continued stimulus it no other contraction followed.

If a limb is nearly excited, whether dry, that break stimulus are applied to it, or that its excitability has diminished, not long, it stimulates remain long latent, but it is now no longer propagated to the other limbs. Sometimes the peculiarly becomes obvious where a contracting muscle contracts there succeed a second. When the second is stronger, the other limbs then begin the strong movement with the first. If larger stimulus has no effect, for the first, the second one also remains quiet.

Fig. II

[Handwritten notes and diagrams with various annotations and corrections]
If the fatigue proceeds, the other links are not participating in the second strong contraction, but after in advance it may take place in both links after longer latency. To what degree however a certain succession of weak stimuli make increase in an irritable link is shown in Fig. 10 (pase mile), the number of the most length of the original must here be made in shortened time.

He sees that 57 seconds of stimulation are necessary like the first preliminary contraction (degree I) appears; from this 39" here till the second, till the third there is a diminution of 18" stimulation of 18" till then till the fourth 43" time of stimulation. After 27 other seconds of stimulation the link makes a series of double elevations and depressions, does not come to rest at once after the stimulus has ceased.

After a short pause (16") the skin of the tender link stimulation further is 4 and the same way, even the force of stimulation for few minutes, no more effect could be obtained. The stimulus strongly but an interval of 1/2" however produced powerful reflex after 15" latency.

If after such a rapid discharge further stimulation is carried out, an irritable links with moderate intervals of stimulus and merging remains a long time at rest. Then it can be made to produce another perhaps ever-changing, but constant train of potenti differential after discharge.
Here should come the paragraph scored out on p.58&59.
Thus, the response was noted Friday, stimulation with 100" of air space lasting a long reflex epoch after 2.5" latency of 8.5" duration. Then, the continued stimuli increased 35" latency but now produced a contraction of degree III. Then nothing more even after stimulation for two minutes. The unit, however, was not means dead, for gentle mechanical stimulation produced toward the end of this period of stimulation a strong reflex.

After rest for several minutes, the same stimulus was capable within 1.5" of producing repeated brief contractions (degree II). Hence, however, the unit was by bands for the whole remainder of the time of stimulation. From three minutes, rest of 0.6 minutes, return to the line, kept of thought. Without it, did not even require the bands test. Even 10" restored to the preparation a great part of the reflex capability. This also proved what has been indicated (3), that even sub-maximal stimuli failed to give the reflex preparation. For recovery however, a very short time is required.

Can one, however, apply the stimuli that its motor effects may sum themselves up, but not its reflexive effects? This formulation seems to involve a contradiction in subjects. Then if the movement is kept up from stimuli to stimuli, only the
resulting movement, not the producing movement itself, fatigue, then just as the internal activity increases, must the inhibitory activity. If in the contrary case we regard the reply discharge as the resulting effect of independent opposite forces, accelerating and inhibitory, there is nothing in the way of conceiving the first with a certain succession of stimuli, the inhibitory factor is only able to form themselves up in a nervous form, whilst the impulse to movement lasts longer than the intervals, that by appropriately arranged pauses the small time for recovery is preserved to the nervæ rerum, which is not sufficient for the inhibitory ones. After the previous discussion one may doubt the existence of a succession of stimuli, with which the after-effect of the shocks lasts alone a short time. The greatest possible interval of stimulus cannot, characterized as 2.5", have shown at the same time, that stimuli of so slow frequency render but to lose their after-effect must be very strong, this consequence from also with the hysteresis. But this have been from the result of other experiments upon animals that reflex reflexes last longer than the motes, sometimes in a pronounced degree. At ray it appears that internal movements increased to a considerable intensity act for longer time afterwards, then the individual shocks.
It must be possible to a certain extent for Sems to keep themselves up, such must bear large intervals of stimulation. In fact I have succeeded in making the after-effect of the reflex excitation visible for longer than 12 bee's times of rest. The sluggish preparation required almost 1000 units with interval 2. The small series of 4/4th. to be arranged in a tabular form.
<table>
<thead>
<tr>
<th>Period of Rest</th>
<th>Passive stimulated</th>
<th>Period of stimulation</th>
<th>After contraction</th>
<th>Sensation remaining</th>
<th>Maximal height of force in millimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5&quot;</td>
<td>2.0&quot;</td>
<td>8.0&quot;</td>
<td>8.0&quot;</td>
<td>2.0&quot;</td>
<td>9.0&quot;</td>
</tr>
<tr>
<td>11.0&quot;</td>
<td>2.2&quot;</td>
<td>6.0&quot;</td>
<td>6.2&quot;</td>
<td>2.4&quot;</td>
<td>5.0&quot;</td>
</tr>
<tr>
<td>11.0&quot;</td>
<td>2.3&quot;</td>
<td>6.0&quot;</td>
<td>6.0&quot;</td>
<td>2.7&quot;</td>
<td>6.0&quot;</td>
</tr>
<tr>
<td>12.5&quot;</td>
<td>2.5&quot;</td>
<td>6.0&quot;</td>
<td>6.0&quot;</td>
<td>2.5&quot;</td>
<td>5.5&quot;</td>
</tr>
<tr>
<td>10.3&quot;</td>
<td>2.0&quot;</td>
<td>7.0&quot;</td>
<td>4.2&quot;</td>
<td>0.0&quot;</td>
<td>5.0&quot;</td>
</tr>
<tr>
<td>12.0&quot;</td>
<td>3.0&quot;</td>
<td>13.5&quot;</td>
<td>10.0&quot;</td>
<td>0.0&quot;</td>
<td>2.0&quot;</td>
</tr>
</tbody>
</table>

The excitations keep themselves up for a period, without the height of the preliminary contraction increasing, so that the length of the rhythmic after-effect becomes considerably reduced. After the strong discharge, however, only small reflexes were obtained. One can scarcely assume that in this case the facilitation was not increased but only the excitability. It is scarcely to be believed that 30-40 ordinary strong stimuli, which are able quickly to kill the preparation, should previously have increased the excitability. The most probable view is that neighbouring parts are set in commotion or bathed in vibrations from the nearest stimulated central parts. Once movement, when the external stimulus continues, always goes further (since the reflexes tend themselves). When a large shock is already in vibration, the primary impulse may be dispersed with for a short time.
Without the whole coming to a standstill.
The powerful new impulses, after a few seconds, if not met by somewhat recovered
fatigue, are able to give the previously reached amplitude to the whole system, and then to
increase it. In regular long intervals (2" to 2.5")
single strong shocks follow, on the contrary they lose their force. The vibrations awakened by
the single impulses do not long preserve their
intensity, remain local. Hence the difficulty
of increasing the small remainder of seldom
shocks, whilst they come to produce fleeting
movements, whereas with rapid stimuli (4" 8"
and) of only moderate strength the preparation
can be brought to modify the most
complicated apparently purposeless waking-
movement, which are so pronounced with
chemical stimuli.

The strong stimuli fatigue specially the
peripheral nerves, the impulse proceeding
from them becomes weaker. Therefore so
that preliminary reflexes are often absent or,
are, possibly from analogy with previous falling
periods of stimulation, they ought to be seen
(Compare Fig. 56, 6, p. 35, 37). A small weakening
of the induction current or of the sensibility
of the nerves is sufficient to prevent the
stimulus from the generally causing a discharge of

[Further text is not legible due to handwriting difficulty]
tible during the Electrical Stimulation, to produce a reflex. The sometimes apparently
stimulated reflex movements. Maclean tried to mediate as automatic contractions (p. 85). The second category of preliminary
reflexes have cited the regular contractions in rhythm with the strong stimuli. They occur very often. Sometimes when the stimuli
stimulated with moderately frequent & intense
shocks. Their size is generally very small some-
times, however very considerable. It makes the
impression forcibly as if the post had moved by direct stimulation of its muscles, but one
can easily satisfy oneself by correct clamping
holding that the contractions also are reflex,
for with fatigued preparations they first
occur after strong, sometimes after long latency
often change their strength periodically.

A phenomenon that shall remain more

The opposition of Mivulzien (p. 84) that
first electrical stimulation of the unipolar
direct & reflex contractions could not be distinguished is also unnecessary for this case of rhythm
preliminary reflexes. Very strong stimuli of
crime also act on the deeper muscles. When
the reflex possibility is nearly destroyed, I
often observed that the strong currents were
replied to by an extension of the foot.
In several cases, this movement was
undoubtedly to be regarded as reflex, for it occurred after a longer latency than could have been produced by pinching the toe of the same or of the opposite foot. But even after complete exhaustion of the reflex, the foot, stimulated by strong currents of limited chiefly the toes, being spread out, involuntarily in consequence of direct stimulation of the muscle. The preliminary rhythmical reflexes, I have observed with the above described apparatus (†) as also on the kymograph. Kymographic account of the lettering, obtained. Here it was possible to include semi-composed reflexes on the piece of paper. But in order to separate on the printing-cord was attached to the motion, so that it was made a small excursion. The movements of the foot were here distinguished from those of the leg essentially by their swiftness. The degree of contraction was noted at the corresponding pl. y. the curve during the stroke. The following begins with an arc of space in divided into two parts, seven an ample of curve or reperfusion. The small proportion of the contraction curve, the normal and abnormal, in order to detect the details, but of a currant flame, at the upper part, it is the observed that, after latent stimulation of 0.2 to 0.5 sec. The rhythmical reflexes began it after total latency of 13-18" passed into the final elevation of the body, so that there the released lever could mark its true first. At a little higher level,
The foot of the suspensory ligament appears to rest upon the flexor surface, invariably and within narrow limits. The weight of the upper limb (viewed from left to right) straight at rest at the hand, or in motion, when it is rhythmically displaced backwards by the foot in the converse. The middle limb is

high curve indicates that the skin was touched at the midline with the rubberized discharge of 155.54 millimere, by lowering that the midline was interrupted. The lowest limb marked the second division into three. Fig. 1 gives neighboring parts of the curve which belong to the long stage of fatigue, Fig. 2 gives three somewhat later stages.

When the reflexes are resolved the hand fell backward against the central figure. The check (made of a thing-like band and somewhat downward), it returned to its equilibrium after one, then after several after which, was to be obtained in the 3rd to 4th period of Fig. 11a. Thus the beginning and end of the reflexes, is most pleasing to note. Only when the condition is very flat are descending, voluntary observation must control the apparatus. In the curve of Fig. 11, we observe that the latent time of the preliminary reflexes have
Laterally equal (0.2° - 0.4°), that the final reflexes however on several require larger latent-times (1.9° to 2.2°). At the same time the second Fig. shows that with long continued stimulation the final reflex to turn yields no influence on contraction of the foot-apex occurs.

The existence of the latent-time estimates throughout the Figs. show very few differences. The final reflexes of the frog preparation occurred after strong stimula (70 volts) after 20 short times, that the rapidity of the cylinder of the dynamograph was not rapid enough for their measurement. Whilst in the highest stage of fatigue 12 seconds latent stimulation were noted. The preliminary reflexes also sometimes become obvious first after latency of several seconds.

The next Fig. (12) gives an example of a very regular dancing movement of the foot.

Reflex preparation stimulated by induction shock of 100 Electron.

In the figure, with the end of a metal needle, the contraction is the foregoing figure. Only the stimulating current at the time marking the time the curve above the contraction curve at the middle line marks the descent the beginning of the stimulation.
In this case the foot replies to only every second
stimulus (opening, shock) to reach it to the clavi-
- shock invisibly, exactly like a speedily stimulated
over-weighted or a fatigued muscle. The reflex
nature of the contraction is also proved here
by the length of the latent stimulation beyond
the further reflex period of the preparation.

The increase by the at first invisible
thymicale contractions, what have never
occurred by stimulation of moderate frequency
applied to muscles. In the above preparation
the long series of vibrations of the foot before
the production by the high reflex contraction
we also noticeable. The neighbouring contraction
was produced by straight stimulation
125 E. Contains a much shorter stage of
preliminary reflexes 2 is the latency till
the final reflex is shorter than with
more strong stimulation.

I also employed another exceedingly
sensitive method for registering the results
of the most rapid reflex contractions, on
the beam of a Schottmann's reflector
where cork plate was fixed, to an turn
the toe of the preparation. The platinum
shuttle at the other end of the anchor beam
dipped into a small vessel of Hg. remote
as the foot removes the weight from
the double lever.

The closed current permitted the anchor
beam, provided with a writing stylus, to track
the moment of their with the rhythmical succession
of contractions a fair looked curve, obtained,
with the longer contractions, for flexor reflex
appears a long mark II. The curves are very
constant for measurement on account of
the sharpness of the moment noted. This array
may also permit of every manipulation
during the course of the fit, because may
stay as far removed from the muscularity
as be will. Lastly, the method is to be counted
for a large circle of known for an electric
bell marks very pleasing the succession of
reflexes, by allowing it to sound as long as
the limits to paused. The question is at hand
are these rhythmical reflexes fundamentally
different from the formerly observed single
intrinsic contractions.

Later on, Hales support the view that:
Every stimulus adds an increment to the move-
ment of the reflex centres, that several single
shocks sum themselves up till the centres
of stimulation is overcome or passed, &
a preliminary contraction occurs, that then the
stimulation goes further, like a final
contraction, or an intrinsic attack closer the
reactions. The further movement is all
not caused to cease by every small
contraction, but only by strong discharge.

They should not every stimulus after the
first had has been once reached of the summata
Of others, we are the remnant of their effect to
an end reflex just as the body to we have
been the primary small reflex forms heads
themselves up to make secondary ones.

Real-regularity or equability of the stimulus
habitability are necessary there to. Such a prep
is only a special case of the general. To
round this view then present some forming
discharge, which show the passage of reflex
desires into the periodical ones.

The major idea of this cathode tube curves had a path and the
ris reflex presentation where middle joint had united with
the rising lever, and stroke upon another paper. We are
preparation was performed by graduation current
of removal 30 E at which each 9 V, the other bit straight
of current 20 E in 1/2 "hit. The middle line through an
horizontal the time of a second. The lowest line
mark second.

The first curve shows a complete reflex period
with sensory chemical moderate reflex.
Ph. appears after short latency (almost 1") increase after 5" latency to a peak, which curve the accompanying impulse it as it to be recognized.

The second curve represents a group of reflex contractions that were produced by stimuli shock of intensity 1/2" after 5" latency duration. The preliminary pulse follows each after a duration of about 1" and increases rapidly to maximum contraction.

The third group lasts five, the last piece of a longer period of stimulation (20 E) ½" just m. n. before this discharge single preceding one follows. After 18" (degree I) 14" (degree II) 20" (II) 28" (II) 31" (II), then there occurred the first. Small elevation of the left foot. After 38" (total latency time) at intensity 1-1/2", a complete discharge was produced, (m. t. exceeds the former due more than can be given to the limited space). Here there are elevations of the left m. precede swiftly, or in rhythmic order one reflex precede the second reflexes. Then the latter again relatively weak stimuli Co great that we can see clearly unguide that secondary loss of current, m. T. all to the flexors of the leg feel as direct muscle action.

Fig. 14. Ref. to illustrate an allied question gives an example of a rhythmic succession of small reflexes m. m. were also written by the leg. In my curves of Fig. 15
there are also a number of pictures, which serve as intermediate stages to the above. I have series of large reflexes following in half system of the stimulus, r.h. alternate with single cell. In Fig 8 an example is given in r.h. from the middle of the series onward in every 4 ft. A weak (I) initial reflex occurs, to r.h. after a pause the strong reflex (III) succeeds, also in the latency curve. Fig 8 several preliminary reflexes are indicated by rings. These follow each other at very unequal distances, place near to those where compound discharge has to be obtained. In comparing these modifications, the belief is found, that the simple final discharges to the isolated reflexes of Fig 9 & 10, from there to the ring in the one of Fig 11 & 12, come to the conclusion that between the complexity of the units a distinct number of combinations is possible through the number of stimulae. When however one takes into count the continually variable height of the contraction, one finds this number.

Up to this time on account of compact I have generally termed the first strong reflex "preliminary". With great right too, for he have already remarked, with Marcell, M. it is extremely moderate or near stimulae that no reflex simply follows the first strong, simple or spasmodic attack of reflexes in the same period. It is not
It is quite different however with susceptible preparations or those treated with minute stimuli. Here many very often high contractions follow at short-acting intervals. After some time the discharges become smaller and smaller, irregular, and disappear completely. The stage before the last requires special consideration. If the preparation is only capable of making strong or weak reflexes, the contraction have we to regard as preliminary. Then can we predict the stimulation as not likely to give us a peculiar? Rosenthal (1873).

It is the formation of the "Reflexzeit", but not of the "Reflexzeit". This rule holds that for the development of the "reflex development" which leads to the "mature" and "unmatured". In my opinion, I could not follow this system without losing many valuable data. Had I omitted the points marked in Figs. 4 and 5, then numerous disturbing imperfections would have been left. Compare L. J. Figs. 5.

How often have we, in fact, at the typical splits instead of the maximum contraction (1) made of degree II, or even I, or on the other hand, some strong spasmodic like no (1c). Similar results are found in the case. From this it appears that it is not the
Strength in the test of the reflex contraction
Mr. is of fundamental importance, but the
circumstance whether a complete discharge
has taken place or no?

What process however can we charge
as a complete discharge? This is the most
important question. We have to know an
on the course of this investigation.

When we observe a reflex preparation,
Mr. requires moderately strong electrical
cutaneous stimulants. If it is in motion it
heat is with moderate frequent shocks
the frequent observe that, the foot of
its half time, exhibits psychological movement.

This heating of the foot as it were, with a
half length of the stimulants gradually became
change, taste or heat reflex results.

When the preparation is still more
worse, the leg begins at once to heat, bend,
curve like the feet of the following
employed. Fig 14. Of the vibration is
weaker (because stimulants slight being have
diminished) then there is no longer a feel
when (fig. 13) but vibrations of the foot or
small ones of the leg only increase to weak
movements of the leg.

Such a condition is present at by the
second curve of Fig 14. Or slight, one
observe, that only the rhythm the beat of the
foot periodically diminishes increase with
out the leg being moved also. Under the preliminary contraction of these, often several times, during a period of stimulation, it frequently happened that the first group did not cause elevation of the leg but after several, often many minutes, complete, that the movements of the foot reappeared. In some cases, movements of the leg, or even to those of the thigh.

**Fig. 14**

Reflex preparation. Butterfly at intervals of 1/4" with 25 E. + 20 E. (intensity) and noting its contraction if ever attached to the ankle joint. The middle line indicates hydration of the minislung, the lower one seconds.

The elevation are often repeated several times in a period. One has some experience in such observations, observing the limit during a longer period of stimulation.
It is possible to predict
whether a reflex may be expected or not.

As Edward Weber compared the intermittent movements
of the reflex excitant limbs with an animal "fur-wielding
Artemisia Macht" to (might I call the former described a
Sphynx-After-Weber to the result-
(the production of a powerful reflex), the force which
of the most done becomes in vain, must be done
again from the beginning. This appears to me to
indicate the amount of production. A simple
or complex production exhaust the store present.

In fresh preparation, this can be repeated
covered. The energy becomes dissipated by the
stimuli, its perfection by the degenerating meta-
metaphor. Even minimal excitations will produce
even the most localized reflexes in the foot,
appear to fatigue, for there, alone, he has been
to exercise himself, to decrease, to disappear,
but the diminution of irritability appears to be
very evident. Each vibration, often last for
minutes. The process may be made clear by
simple comparison. A pendulum receives a
minimal impulse, to be raised a little from
the position of equilibrium; returning it can
only overcome very small resistances. When raised
higher it gains in the return greater velocity to
with a corresponding mass it is able to carry
greater amount of potential energy to a resisting
body. If the resistance is not great, the pendulum
repeats the remainder of its course in rising in the
opposite direction. On returning it can again
overcome resistance, so as until its energy is used up, until its velocity and position of equilibrium become invariable, and last stands still. Imagine further a second pendulum, of the same length, placed with regard to the first one, so that both planes of vibration are parallel. A self-oscillating process (e.g. a pair of watch-springs of small elasticity) is first to the second pendulum, so that the first pendulum, in passing it, touches the position of equilibrium, with small impulse, the spring will be only slightly compressed, and insufficient energy to be bent. The process conveys the shock to the second pendulum; the more, more nearly than the first, the more hindered by the resistance, but not brought to a standstill. With greater slowness the first pendulum falls with great velocity against the spring, passes it, aside to complete its other quarter of its vibration. In the mean time however the second pendulum has also taken up the part of the force for which the spring was still bent. It makes a small vibration but as its duration of vibration is equal to that of the first it is also a quarter vibration, & arrives in the position of equilibrium simultaneously with the first pendulum. Here it receives from the rapidly falling pendulum the initial impulse, & the again partly conveyed to the spring. The impulse of the first pendulum seems to themselves, up to their action upon the second, at last, it may reach the full amplitude of the first.
The employment of picture for the reflex process is obvious. We only require to conceive that the force of the motor nerves is applied to the first pendulum, that the next sensory nerve receives one impulse from the pendulum, as soon as this passes the position of equilibrium on its return. The end of other nerves are set in motion by the second secondary motor pendulum, as soon as the kinetic energy of the shocks has exceeded a certain limit. A third similarly coupled pendulum would require a vibrating complex of the third order. To explain the consumption of muscle with secondary tertiary production per must introduce into our picture a complication that at the moment, when the force of the secondary and the tertiary pendulum become sufficiently increased, to introduce a motor process in the end of the series, when a sort of 4 flow is taken place, which sends the motor impulse toward the periphery, but also reach upon the centric.

The production of heat is the production of acid maybe partly the cause of the deadening of the central tractibility. By phlegm discharge, the whole system becomes moveable with peculiar signs, so that the centrals from one vibrating system to the other lasts very long, until force sufficient for the production of a reflex act reaches the second or third by them. But the phlegm of the centric partly does not require to bear the blame of the weakening of acentric thing. The reflex act being may also require to act, if it cause the sweat to the central insufficiable.

This is easily known, by letting the reflex insufficiable often observed bile from the other bile. Frequently, Phlegm.
When very strong cutaneous stimuli in large intervals, have acted without much effect, are found to act with but little retained. My experiments are insufficient to decide the very interesting question, whether the non-sensible cutaneous, sensory no longer influence the centre. There will remain to be explained an essential point of fundamental importance for the principle of summation.

Up to this time we have regarded the reflex-actions as far as they are the effects of summated electrical induction of stimuli, the mere of the operators, no matter possible, or far, or by far, reflex-effect weight. It has now to be asked whether a reflex-action can occur without the summation of stimuli. This seems important. A point is sufficient to cause an animal to fly away, pressure in the post-epileptic zone to occasion a quickstart. The very short time turning the charge of a depolarized have been found by Caravelli. Voletta (in Boga Rejehrandthetk, when Ohmike Electrical, 1848, B. 8, p. 290) to act on the sensory nerves of man and fish, Seidler, Frei, who have in the adductor, have been different for the effects of single electrical inductions (interruption of the current, induction shock). They have already occasionally remarked that with very strong, seldom stimuli applied to post-epileptics, the reflex occurs earlier than the second shock. All experiments agree in this. That for reflex-epileptics with single induction-current, quite incommensurable, specific multiplied by the current are very long for stimulation of motor nerves, whilst, for summation-reflex, comparatively weak stimuli are sufficient.

To find out the cause of this remarkable effect,
Please find the effect of single induction shocks, in several ways, compared with the effect of repeated
stimuli. The following is the result of my tests, with single
induction shocks.

Refluxes were only produced by single simple (always applied to
the skin of the leg) induction shocks when they were very strong. In
most cases the brief reflex was a few times, to the stimuli given
when longer rest was given between the shocks. By replacing
preparation could hold out 30 such stimuli. There must
however at least be increased to 1-0 or even higher. The latency
increase to 3-0 times higher. The latency of the latent-line with
hottest made from the following for a minute curve, then by
number. (Fig 15 a No. 1).

Describe at all parts of the curve, with the exception of the
first (P1) two or three differently formed parts, a positive, slow
elevation of a very well-formed (between a behind) a pure
temple or double tooth. The meaning is clear. The first
point represents the composite curve of contraction, or
follows direct stimulation of the motor elements of the
limb without Brown's latency. In the first period (P1) the
remains invisible, because it is limited to the long latency
and not till little latency before the first one converges
from the maximum. In the other represented periods the
on the original paper almost constant Kelly follows each other the curve the curve of contraction always
further removed from the one directly rated. They resemble
as lethal characteristic. Sometimes with additions of
acute processes. The right face of the writing pen letters
the curve of contraction more than the contraction are not
due to sluggish movement of the livers. The reflec-
The left post-op a large group rested on the already described posterior lever. An additional shock (opening) diminishes it in each of the 6 periods (P, 6P), 700 E. After each stimulation there is a minute rest. The stimulus then makes a notch upward when the primary current is opened. The time marker note, seconds (0 below, 2 above).

The reflex latent time in P, reaches the value of 7.

The increase of the latency with the fatigue is also a common phenomenon in the reflexes produced single contraction. The dependency of the duration of latent stimulation upon the activity of the current in rectifier proved, because the strength must be increased, in order to obtain a larger series of reflexes. In some cases, where it was possible to compare a series decreasing strength of current, the activity appears to be variable under the latent time.

The closing condition - those are constant in certain cases, capable of random reflexes. They are always observed in the vicinity of the angle of the opening shock. The closer, the more 600 produces reflex contractions.

Both papers are referred to in Wiedemann's
"Lehre vom Sulf von Isomere und Diast.
- magnetische" 2 Auflage, Braunschweig,
with latencies from 1.25" to 1.75" 900 E and any was determined

to 6.7". Opposite shocks of equal intensity at the center
produced strong contractions after 0.7" to 0.8" latency.
Now when the opening shocks indicated the same, many
oscillating discharge has been found (Defrance,
Process, Verhand ling van de Akademie te Amsterdam
(768, 788, 881), so the thought underlying these, ne-
that their reflex contractions are also to be regarded
as summation effects. In fact, as single hundred-
shocks of the smallest intensity (700 E to 900 E) acts
just after large latency 11.7") then had no more
Thus, lasting stimulation of moderate strength
100 E) gave reflex contractions, after indirectly
short-latency. This result was in the highest-degree
striking because according to the usual views, it is
difficult to understand, how one thing stimulates
several, a greater threshold of stimulation than
many weak ones. To explain this, we will consider
here made, in all the resulting effect of an single
shocks was compared with that of long following-
that in different-intensities.
At first a closing shock acted like an opening
shock 600-700 E after latent times, 90.7-0.6".
Successive shocks following each other at an
interval of 1" was able to turn up the effects
similarly to a change of reflex than the single reflex. Dully
applying the ordinary opening and closing shocks
this has still possible at intervals of 3". If,
ever this stimuli followed each other at an
interval 1/2" was shorter than the observation of the
deviation of the latency stimulation of a single shock (0.2") then the reflex followed almost immediately.

It is after the second stimulus, i.e. after an equal distance, than after equal strength stimulation.

Hence, Herren's method that the observed time of latency stimulation does not give the true value of the capacity of the fibres with their connections to peripheral motor units. For it would not be possible to see how a second stimulus alone would cause earlier, than an equal strength start, but that the estimation of the latent stimulation also includes the time, which is required for the movement in the peripheral cord to the threshold.

This view would accord with that of St. Exner who defines the "redundant reflex test" or the term "delche der neurone einen gebrauch machen, wird der sensible faden durch den sensiblen faden durch die nerven in den menschen" (Pflügers Arch. f. Physiol. 9, 270).

Regarding the question how it comes, that single stimuli can cause summation effects is indicated by Duglise (Pflügers Arch. 87, 22) very thing reduction - shocks add by changing the nerves. Normally (chemically). In fact be my experiments, I have observed that - a sensitively nerve fitted with single shocks of the strongest sort pass directly into a latent, which must be produced from the indirect stimulus. Many observers have long ago proved that applies to the sciatic nerve (a single strong and short shock is able to produce tetanus in theSciatic nerve). But I must believe I have shown that the above
Single stimuli could also be lumped into the category of the summated ones if we can say! Reflexes can only be produced by repeated impulses to the nervous centre.

The results of the above two experiments find their confirmation in many experiments, we can make on ourselves; reports of the oxymoron, however, of the nose is manifest, by the produce of a sneeze. Coughing yields a splendid sample of reflex emission from summated stimuli. We feel a paroxysm of the pharynx of the muscles membrane of the larynx. The slight sensation increases without a new cause taken. Sometimes, probably we feel that it is necessary to sneeze; when follows a strong cough. If this is not capable of removing the offending body, the violent elevating myofibrils increase to violent spasms. A stage of fatigue follows the violent exchange; the fatigue giving rest, in spite of the summation of the stimuli until the expectation again becomes active. But even when the offending body has been expelled the feeling still remains for a time; it is pressible by mild coughs, with a certain amount of rapid muscular just like the after swallowing.

The sensation without reflex conveyance can also be increased by gentle stimuli, intermittent
gentle tapping of the skin produces tickling pulses,
Mr. their late continued becoming great
measurable. The irritation, persistent, they can
\( \frac{d}{dt} \) seldom make pocks plaits intense remain
men into a great state of excitement. A
strong blow, or pressure of cut-cause easier
be borne.

W. Hunter M.D. M.B.

Edinburgh, December 11, 1875.