DECEREBRATE RIGIDITY, AND REFLEX COORDINA-TION OF MOVEMENTS. By C. S. SHERRINGTON, M.A., M.D., F.R.S. (*University College, Liverpool*). (Three Figures in Text.)

1. Decerebrate rigidity.
2. Afferent nerve-roots and decerebrate rigidity.
3. Forms of extensor rigidity allied to decerebrate rigidity.
4. Inhibition of decerebrate rigidity by central stimuli.
5. Inhibition of decerebrate rigidity by peripheral stimuli.

1. *Decerebrate Rigidity.*

IN a communication to the Royal Society in 1896[1] I described under the name *decerebrate rigidity* a condition of long-maintained muscular contraction supervening on removal of the cerebral hemispheres. The condition is one possessing considerable physiological interest, but I have not succeeded in finding any description of it prior to the above mentioned. Although continued experimentation still leaves me in doubt concerning the actual focus of origin of the rigidity, it will be useful to give here a further account of the phenomenon and of some points connected with it.

When in the monkey after ligation of the carotid arteries and under deep chloroformisation the cerebral hemispheres are removed, and little hæmorrhage has occurred, the respiratory movements proceed, after a slight temporary check, regularly as before, and the chloroform narcosis can be somewhat relaxed because profound unconsciousness has resulted from the ablation itself. Then ensues, often almost at once, *i.e.* in a few minutes, sometimes however only after an interval of an hour or more, a status characterised by a peculiar rigidity of certain joints. The elbow joints do not allow then of the usually easily made passive flexion, the knee joints similarly are stiffly extended. The tail is stiff and straight instead of flexible and drooping. The neck is rigidly extended, the head retracted, and the chin thrown upward.

[1] *Proc. Roy. Soc.* LX.

In my observations I have been accustomed to support the animal freely above the table. In that way opportunity is afforded for separate inspection and investigation of the individual parts of the trunk and limbs. The joints are then free to move with little hindrance. Moreover the existence of and even the degree of paralysis of different regions is indicated very valuably by the extent to which the attitude is determined by mere gravitation. If in a monkey or cat transection below or in the lower half of the bulb has been performed, the animal, artificial respiration when necessary being kept up, hangs from the suspension points with deeply drooped neck, deeply drooped tail, and its pendent limbs flaccid and slightly flexed. The fore-limb is slightly flexed at shoulder, at elbow and, very slightly, at wrist. The hind-limb is slightly flexed at hip, at knee and at ankle. On giving the hand or foot a push forward and then releasing it the limb swings back into and somewhat beyond the position of its equilibrium under gravity; and it oscillates a few times backward and forward before finally settling down to its original position.

To this condition of flaccid paralysis supervening upon transection in the lower half of the bulb the condition ensuing on removal of the cerebral hemispheres offers a great contrast. In the latter case the animal, on being suspended just in the same manner as after the former operation, hangs with its fore-limbs thrust backward, with retraction at shoulder joint, straightened elbow, and some flexion at wrist. The hand of the monkey is turned with its palmar face somewhat inward. The hind-limbs are similarly kept straightened and thrust backward; the hip is extended, the knee very stiffly extended, and the ankle somewhat extended. The tail in spite of its own weight, and it is quite heavy in some species of monkey, is kept either straight and horizontal or often stiffly curved upward. There is a little opisthotonus of the lumbosacral vertebral region. The head is kept lifted against gravity and the chin is tilted upward under the retraction and backward rotation of the skull. The differences in general attitude assumed after transection in the lower half of the bulb and after ablation of the cerebral hemispheres respectively is indicated in the diagrams Figure 1, *a* and *b*. When the limbs or tail are pushed from the pose they have assumed considerable resistance to the movement is felt, and unlike the condition after bulbar section on being released they spring back at once to their former position and remain there for a time more stiffly than even before.

The phenomenon of this decerebrate rigidity occurs with little

variation in the monkey, dog, cat, rabbit and guinea-pig. In all these species the effect upon the fore-limb seems more intense than on the hind-limb. In the hind-limb the knee is the principal joint affected. In the rabbit the phenomenon in the hind-limb has so far as my observations go been particularly well seen. It is noteworthy that the wrist and ankle are comparatively slightly implicated in the rigidity, the ankle more than wrist. I have never in any instance been able to satisfy myself that the digits are implicated at all.

The rigidity is immediately due to prolonged spasm of certain groups of voluntary muscles. The chief of these are the retractor muscles of the head and neck, the elevators and dorsal flexors of the tail, and the extensor muscles of the elbow and knee, and shoulder and hip. This prolonged spasm I have seen maintained in young cats, with some intermissions, for a period of four days. It is increased, and even when absent or very slight may be soon developed, by passive movements of the part. For example, passive flexion and extension of the elbow will suffice to "develop" in a few seconds a high "extensor rigidity" of that joint. This will after continuing a short time then tend to slowly relax again and then again it can be re-called by repetition of the passive movements. There is no obvious tremor in the spasm in the earlier hours of its continuance; later it does sometimes become tremulant.

Administration of chloroform and ether, if carried far, quite abolishes the rigidity. On interrupting the administration the rigidity again rapidly returns.

Section of the dorsal columns of the spinal cord does not abolish the rigidity. Section of one lateral column of the cord in the upper lumbar region abolishes the rigidity in the hind-limb of the same side as the section. Section of one ventro-lateral column of the cord in the cervical region destroys the rigidity in the fore and hind-limbs of the same side.

It would be possible to ascribe these results to interruption of the pyramidal tract. The following however cannot be explained by appeal to the pyramidal system. Section of one lateral half of the bulb in the lower half of the floor of the fourth ventricle and quite above the level of the decussation of the pyramidal tracts abolishes the rigidity in the limbs *on the same side as the section.* And, further, transverse severance of the lateral region only of this part of the bulb without interference to either pyramidal tract produces similar abolition of the rigidity of the homonymous limbs. Finally, excitation of this lateral region with

rapidly alternating series of induction shocks reinforces the rigidity in the homonymous side.

If instead of both cerebral hemispheres one only, say, the right, be ablated, the decerebrate rigidity appears, though not with the same certainty as after double ablation, chiefly on the *same* side as the hemisphere removed. The monkey when slung after ablation of one, *e.g.* the right, hemisphere exhibits generally the following attitude. The right, limbs are extended in the pose above-described as characteristic for decerebrate rigidity, the tail is strongly incurvated toward the right, that is, its concavity is toward the right and its tip is also toward the right. It resists passive movement to the left, and if displaced thither immediately on being released flies back. The head also is pulled toward the right and retracted. The left fore-limb—and the point will be returned to—is sometimes distinctly more flexed than would be expected in the paralysed condition of the animal: the left knee likewise. The same results are seen in the cat. The contrast between the attitude of the crossed and homonymous sides is very striking. They are indicated by the diagrams Figure 1, *b* and *c*. The retraction
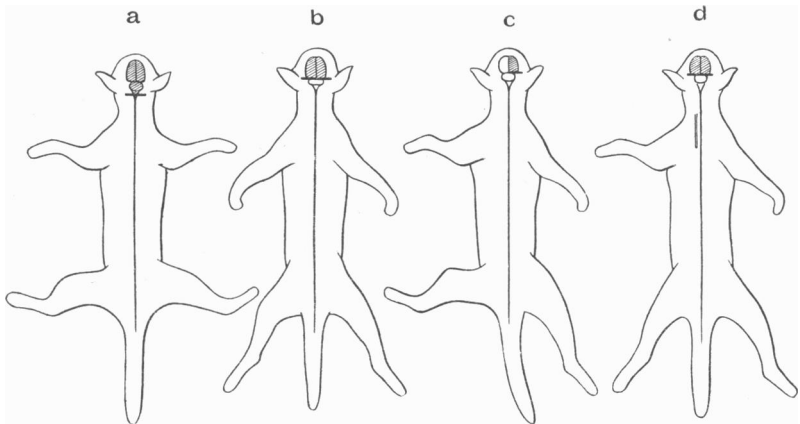

Fig. 1.   *a.* Position of animal after transection at calamus scriptorius.
       b. Position of animal after ablation of cerebral hemispheres when decerebrate rigidity has developed.
       c. Position of animal after ablation of one cerebral hemisphere when decerebrate rigidity has developed.
       d. Effect on decerebrate rigidity of severance of afferent spinal roots of left fore-limb.

and bending of the head cannot however be well shown in a diagram taking the dorsal view.

Homonymous extensor rigidity consequent on ablation of one hemisphere is however neither so constant of production nor so persistent when it has appeared as the rigidity following bilateral ablation. After coming on it may totally subside and again reappear, and so on several times over. There would seem under these circumstances a struggle between two conflicting influences, as though a tonic influence from the still intact crossed hemisphere at times overcame and at times was overcome by another opposed influence from a lower centre. Some amount of extensor rigidity on the side opposite to the lesion is not uncommon.

2. *Afferent nerve-roots and decerebrate rigidity.*

If after ablation of both cerebral hemispheres, even when the rigidity is being maintained at its extreme height, the afferent roots, which have been previously laid bare and prepared, are carefully severed, the limb at once falls into flaccidity. From the stiffly extended position it drops into the slightly flexed position it assumes when flaccid under gravity. The result is quite local, as indicated in Figure 1, *d*.

A question arises; is this setting aside of the rigidity by severance of afferent spinal roots a result of their paralysis or of their irritation? Is it due to pure interruption of the afferent path leading from the periphery to the spino-cranial centres, or is it due to mere irritation of the afferent fibres by the mechanical process of severing them and the irritation of the injury set up in them? The former seems the explanation on the following grounds. Firstly, the abolition of the rigidity is long-lasting, *i.e.* persists for several hours, however the mechanical stimulation be minimised, the roots being cut through with as little disturbance as possible at the single closure of a sharp pair of scissors. Secondly, the rigidity develops either very imperfectly or not at all when the afferent roots have been severed some time, *i.e.* a number of days prior to carrying out the operation which produces the rigidity. Of this the following are examples.

Cat. The dorsal (afferent) roots of the 5th, 6th, 7th and 8th right cervical and of the right 1st thoracic nerves were severed in the vertebral canal. Marked ataxy of the right fore-limb ensued with obvious weakness of the right fore-paw (ankle). Ten days later under deep anæsthesia the cerebral hemispheres were removed. In the course of half-an-hour *decerebrate rigidity* fixed both knees and the left elbow in the extended position. The right elbow remained flaccid, although perhaps not quite so flaccid as

is usual after transection at the calamus. After the animal had been subsequently killed, the onset of rigor mortis was much delayed in the extensors of the right elbow as compared with those of the left.

Cat. The dorsal (afferent) roots of the 6th, 7th and 8th right cervical of the right 1st thoracic nerve were severed in the vertebral canal. There resulted distinctly less ataxy in movements employing the paw than in the above example; there appeared also less weakness at the wrist, but in the erect position the animal stood with its left wrist less dorsal-flexed than its right. In jumping the animal appeared always to alight on the left fore-foot a little before the descent of the right. In walking each step forward with the right fore-limb brought the foot far round, sometimes even to the left of, the left foot. Twelve days later the cerebral hemispheres were removed under deep anæsthesia. *Decerebrate rigidity* rapidly ensued, fixing in the extended position both the two knee-joints and the left elbow; but the right elbow remained flaccid. After killing the animal rigor mortis set in much later in the right than in the left triceps. Histological examination of the spinal cord revealed degeneration in the dorsal column of the right side but no further lesion. The ventral (motor) roots were quite intact.

Monkey. Macacus rhesus. The afferent (dorsal) roots of the 5th, 6th, 7th and 8th left cervical nerves and of the left 1st thoracic nerve were severed in the vertebral canal. Marked ataxy of the left arm ensued. The movement of 'grasp' by the left hand was lost. Twenty-one days later the cerebral hemispheres were removed under deep anæsthesia. *Decerebrate rigidity* rapidly supervened in both knees and in the right elbow, also to some extent in the ankles and in the right wrist. There was for some time no rigidity at all in the left elbow, which remained flaccid. In the course of three hours the rigidity increased considerably, and there were dubious traces of rigidity in the left elbow; although certainly there was no rigidity in the left wrist. After the killing of the animal subsequently the onset of rigor mortis was much later in the extensors of the left elbow than in those of the right. Histological examination showed the lesion to be confined to the afferent roots mentioned above, and the degeneration to their continuations in the dorsal column of the cord.

Monkey. Macacus sinicus. The dorsal (afferent) roots of the 5th, 6th, 7th and 8th left post-thoracic spinal nerves severed in the vertebral canal. There ensued the usual symptoms of ataxy and enfeebled grasp-movement noted by Mott and myself. The left knee-jerk was abolished. As the animal ran about it kept its left limb flexed at hip and knee. There was no actual 'contracture' in the limb. Five weeks after the initial operation the cerebral hemispheres were removed under profound anæsthesia. *Decerebrate rigidity* soon developed in high degree. Both elbows became fixed in the extended position, as also the right knee. At first there was no rigidity

in the left knee, and later even when the rigidity elsewhere was extreme it was doubtful whether at the left knee any developed; but I do not think the knee was so flaccid as it would have been after transection at the calamus. Subsequently after killing the animal rigor mortis set in much later in the left knee than in the right. Histological examination showed the lesion to implicate only the afferent roots above mentioned.

The decerebrate rigidity seems therefore in some way dependent on integrity of the afferent paths of the limbs. This dependence points to centripetal impulses from peripheral sense-organs of the limb as important for the production and maintenance of decerebrate rigidity in the muscles of the limb in question. Normal tonus of limb-muscles has been shown (Brondgeest, v. Anrep, &c.) to be similarly dependent on centripetal impulses from the limb; and in the case of tonus the afferent paths from the skin have been found less important (Mommsen[1]) than those from deep structures, and especially from the muscles themselves[2]. I find that similarly the afferent nerves from muscles can exercise a great local influence on decerebrate rigidity. Electrical excitation of the central end of a nerve-trunk distributed purely to muscles, *e.g.* the hamstring nerve of the cat[3], produces immediate relaxation of the rigid extensors of the knee. On discontinuing the excitation the extensor rigidity of the knee returns. A ligature drawn tightly round this nerve keeps the knee of the homonymous side relaxed, presumably by acting as a continual slight stimulus. The extensor rigidity of the knee of the crossed side seems on the other hand somewhat increased. Mere section of the hamstring-nerve did not however in three experiments, made with a view to determining the point, prevent the development of the rigidity of the knee.

It is noteworthy that in the second example given above the sensory spinal roots severed in the brachial plexus were exactly those in which exist the afferent nerve-fibres coming up from the triceps (extensor of the elbow) muscle itself—namely, from the muscle especially affected by the decerebrate rigidity. Also it should be stated that in all of the experiments performed the afferent roots cut were roots in which the extensor muscles—the seat of the rigidity—are represented.

These results are strikingly in accord with views that Mott and myself[4] have put forward, and especially with an argument advanced

[1] Virchow's *Archiv*, 101, p. 22.

[2] Sherrington. *Proc. Roy. Soc.* LIII. 1893.

[3] *Proc. Roy. Soc.* LIII. 1893. *loc. cit.*

[4] *Proc. Roy. Soc.* LVII. p. 481. 1895.

by Bastian[1] in discussing the condition of the limb in our experiments on the effect of severance of the sensory spinal roots upon the movements executed by the limb.

J. R. Ewald[2] has pointed out that destruction of the otic labyrinth reduces the tonus of the skeletal musculature of the homonymous half of the body. He also found[3] the onset of rigor mortis delayed in the muscles of the homonymous side. Similarly also I found[4] section of the afferent nerve-roots of a limb delay considerably the onset of rigor mortis in it. Decerebrate rigidity undoubtedly hastens the onset of rigor mortis in the muscles it involves. It seemed therefore desirable to enquire whether section of the nervus octavus would affect the development of decerebrate rigidity. In a monkey the VIIIth cranial nerve of the left side was accordingly cut intracranially between its surface origin and the internal auditory meatus. Nystagmus, lateral rolling movement, and other effects more or less striking ensued. Five hours later the cerebral hemispheres were removed under profound anæsthesia. Decerebrate rigidity then quickly set in and developed with about equal rapidity and in about equal degree on the left as on the right side.

3. *Forms of extensor rigidity allied to decerebrate rigidity.*

While attempting however to obtain as above some nearer view of the causation of decerebrate rigidity it must be added that other mutilations than ablation of the cerebral hemispheres induce phenomena of extensor rigidity bearing at least superficially much resemblance to that produced by removal of the cerebrum.

After median section of or ablation of the cerebellum a rigidity often, but not always, sets in somewhat similar to that ensuing on removal of the cerebral hemispheres. That the two conditions are identical I am not convinced. The uncrossed nature of the decerebrate rigidity suggests a causal connection between the cerebellum and the rigidity, perhaps through the nucleus of Deiters, which as first shown by Ferrier and Turner possesses large efferent connections from the side of the cerebellum. On the other hand the crossed cerebello-cerebral and crossed cerebro-cerebellar paths, in the anterior and middle peduncles on which Mingazzini's histological work has recently thrown more light, may form a circuit whose function is upset in much the same way whether cerebellar or cerebral ablation

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[1] *Proc. Roy. Soc.* LVIII. p. 96. 1895.   [2] *Nervus Octavus.* Wiesbaden, 1892.
[3] *Pflüger's Archiv.* 1894.   [4] *Proc. Roy. Soc.* LIII. 1893.

be performed. This might explain the supervention of a similar condition after either one of those injuries. Median section of the cerebellum also causes some extensor rigidity of the limbs. It will be remembered in this connection that the paths ascending by the inferior peduncle and reaching the superior vermis largely decussate there across the median line (Mott, Thomas, etc.).

It is significant that decerebrate rigidity sometimes persists after removal of the cerebellum, if the latter ablation be performed without any serious amount of hæmorrhage.

These allied forms of extensor rigidity further resemble decerebrate rigidity in similarly being readily broken down by appropriate central and peripheral excitations, among the former of which are to be included excitations applied to the Rolandic area of the cortex cerebri.

4. *Decerebrate rigidity inhibited by central stimuli.*

One of the chief interests of decerebrate rigidity attaches to it as a field for examination of the play of inhibition. For this it gives a wider scope than can be usually obtained, and it has revealed to me an almost unexpectedly significant number of examples of depressor effect generally, perhaps always, in combination with pressor effects, that is to say, in the form of *reciprocal innervations.*

Electrical excitation of the *dorsal spinal columns* in the cervical region provokes such inhibitions. Similarly, as mentioned in my first paper, electrical excitation of the *crusta cerebri* sometimes inhibits the rigidity, evoking reciprocal innervation of antagonistic muscles at elbow, knee, etc. So also excitation of the *pyramidal tract.* In the monkey similar inhibition of the decerebrate rigidity can be produced by excitation of the anterior (cerebral) surface of the *cerebellum*[1], as mentioned in my previous paper. Faradisation of points in a large area extending from near the middle line far out toward the lateral border of the cerebellar surface causes relaxation of the rigid neck and tail muscles, and relaxation of the rigid limbs, especially of the uncrossed side.

But the homonymous extensor rigidity which frequently ensues, as above mentioned, on ablation of one cerebral hemisphere presents an opportunity for examining the effect of excitation of the cerebral cortex itself (of the remaining hemisphere) upon the activity of the extensor muscles of the crossed elbow and knee. I find in the Rolandic region

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[1] In the following year its occurrence in the dog and cat was reported by Loewenthal and Horsley, *Proc. Roy. Soc.* LXI. 1897.

of the monkey a cortical area which gives, markedly and forthwith, inhibition of the contraction of the extensor of the elbow; and another cortical area which similarly when excited inhibits the contraction of the extensors of the knee. This is in accord with the results obtained under different conditions by H. E. Hering and myself[1]. Also, as Hering and myself in those other experiments noted, the areas of cortex whence inhibition of the active extensors is elicited are not the same areas as those whence contraction of the extensors is elicited, but on the other hand coincide with the areas whence· contraction of the flexors can be excited.

5.   *Decerebrate rigidity inhibited by peripheral stimuli.*

Besides the inhibitions from the central nervous system   inhibition of decerebrate extensor rigidity can be evoked by excitations applied to the periphery.

Thus on excitation of the central end of the 2nd cervical nerve, or of a branch, even a small twig of that nerve, the high-held retracted head drops almost as if knocked down by a blow from above. The muscles causing the retraction can be seen and felt to relax at once under the excitation; the completeness and suddenness of the relaxation is surprising.

Similarly, after removal of the cerebral hemispheres, when it is easy to apply electrodes to the divisions of the trigeminus on the floor of the middle fossa of the cranium, a touch with the electrodes is enough to cause the relaxation of the rigid neck muscles: and the stimulation need not be strong in order to similarly evoke relaxation in the fore-limb, the hind-limb, and in the tail. Indeed the erected tail drops almost as easily and suddenly as the retracted neck. Excitation of even small twigs of distribution of the 5th effects the same; even the faradisation of certain spots of the dura mater suffices. Stimulation of a digital nerve or of the radial trunk causes relaxation of a similar kind, but commencing in the limb. Stimulation of the saphenous nerve as mentioned in my previous paper[2] similarly causes relaxation commencing in the hind-limb and tail.

Electric stimulation of the optic nerve is less effectual.

Excitation of the skin itself produces similar results, and here it is easier to obtain more restricted play of the inhibitions, and therefore results more instructive in regard to the mutual distribution and cooperation of depressor and pressor reactions.

[1] *Proc. Roy. Soc.* LXI. 1897. *Pflüger's Arch.* LXVIII. 1897.   [2] *Proc. Roy. Soc.* LX.

On excitation of the pinna of the ear, *e.g.* the left—whence the afferent paths are 5th cranial and 2nd cervical (in dog, cat and rabbit 1st cervical also) admixed—a complex reflex reaction to the following effect occurs.

The head high-held and retracted, is somewhat dropped and turned away toward the right, the stiffly extended left fore-limb is flexed at elbow, extended at wrist, and brought forward. The left hind-limb is thrust backward, its existing extension at hip and knee being increased. The right fore-limb is thrust backward, its existing extension at elbow and shoulder being increased. The right hind-limb is flexed at hip and knee and ankle. The erected tail is dropped. (Fig. 2, compare *b* and *c*.)
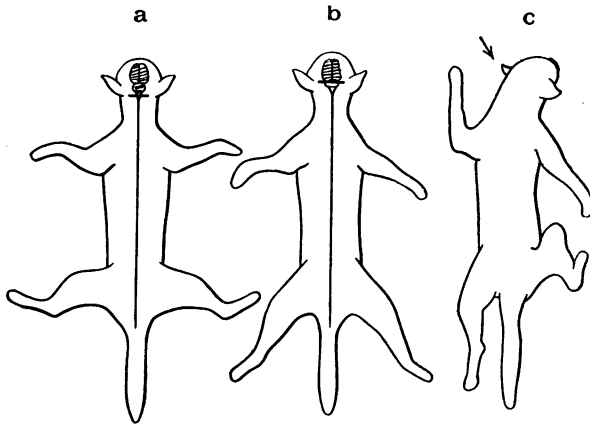

Fig. 2. *a.* Position of animal after transection at calamus scriptorius.
  b. Position under decerebrate rigidity.
  c. Change of attitude from *b* evoked by stimulation of left pinna.

In this reaction there occurs (1) inhibition of the rigid left triceps, with contraction of the antagonistic pre-brachial muscles, (2) further increase of the maintained spasm of the extensors of the left knee and hip, (3) further increase of the maintained spasm of the right triceps brachii with relaxation of the antagonistic pre-brachial muscles, (4) inhibition of the rigid maintained spasm in the extensors of the right knee and hip with contraction of the hamstring and tibialis anticus muscles of the right hind-limb.

In this reflex the turning of the head away from the stimulus forcibly gives the impression of an attempt to escape from the irritation; and the concomitant raising and moving forward of the left fore-paw forcibly gives the impression of an attempt to remove the source of irritation.

If instead of the left pinna the skin of the left hand (or in cat the pad of the fore-foot) be the site of stimulation reaction occurs to the following effect.   (Figure 3, *b*.)
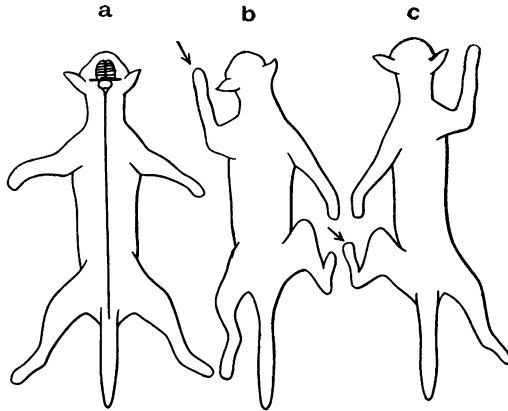

Fig. 3.   *a*. Position under decerebrate rigidity.
  b. Change of attitude from *a* evoked by stimulation of left fore-foot.
  c. Change of attitude from *a* evoked by stimulation of left hind-foot.

The high-held retracted head is let fall somewhat and turned *toward* the side stimulated.   The stiffly extended left fore-limb is flexed at elbow, extended at wrist and brought forward.   The left hind-limb already extended is extended even further, especially at the hip. The right fore-limb is thrust backward and its already existing extension at elbow and shoulder is increased.   The right hind-limb is flexed at hip and knee and ankle, its preexisting extensor rigidity being broken down.   The erected tail is dropped.

Between this reaction and the foregoing the chief difference is in regard to the movement of the head.   In the foregoing the movement resembled one employing the left sternomastoid—but inspection proves that at least other muscles besides the sternomastoids are involved in it. In the latter the movement seems due to lateral flexors of the neck in combination with relaxation of some of the retractors of the head.

If the cutaneous point excited instead of being in the hand be in the left foot (*i.e.* be in cat the left hind-pad) the reaction which occurs is to the following effect.   The extensor spasm in left hind-limb at knee and hip is broken down, and flexion at hip, knee and ankle occurs.   The tail is drooped from the stiff erect position.   The left fore-limb has its extensor rigidity not diminished but increased.   The right hind-limb

also undergoes not a relaxation of its extensor spasm but an increase. In the right fore-limb the extensor spasm is broken down, and the limb is advanced with flexion at elbow, extension at wrist and advancement at shoulder. The head is somewhat drooped. These results as illustrated in the cat are indicated in Figure 3, c. Here again the movement is forcibly suggestive of a *purpose*, namely, the withdrawal of the limb from the place of an irritation.

In this reaction the relaxation of the extensors of the left knee and hip is accompanied by active contraction of the hamstring muscles, of the part of the quadriceps cruris which flexes the hip, and of the tibialis anticus and pretibial flexors, also in some cases of the peroneus longus. The relaxation of the right triceps brachii is accompanied by active contraction of the pre-brachial flexor.

Further examples of local restriction of the inhibitory effect are those which I gave in my first communication: a touch on the skin of the perineum producing inhibition often confined to relaxation of the spasm of the extensors of the stiffly elevated and tonically upcurved tail; rubbing of the cheek producing inhibition of the spasm of the muscles retracting the neck and head.

Regarding the inhibition of triceps brachii and quadriceps cruris, and to a less extent of the gastrocnemius, it is interesting to note that these muscles, which among the limb muscles are particularly difficult to provoke to action by local spinal reflexes, are seen in these experiments to be easily accessible when inhibition and not merely augmentation is taken into account. The well-known observation, first established I believe by Sanders Ezn, that the extensors of the knee are very inaccessible to spinal reflex action, has as I have recently shown[1] certain important limitations. But at the same time so long as the transection is spinal—even when carried out so as to isolate not merely a portion of the spinal cord, but the whole cord entire from bulb to filum terminale—does apply really very strictly to excitations arising in its own local region proper. And the spinal reflex relations of triceps brachii in this respect, and also of gastrocnemius somewhat resemble, as I have elsewhere pointed out, those of the distal portion of the quadriceps extensor of the leg. The difference between the accessibility of the quadriceps and triceps to reflex action after infrabulbar and after suprabulbar transection it seems to me is a matter of superficial rather than fundamental distinction. The *manner* of reply of triceps brachii and quadriceps cruris seems not different in the

[1] *Proc. Roy. Soc.* LX. 1896.

two conditions. When the conduction across a nexus is signalised by a minus sign instead of a plus, the former, to find expression, must predicate an already existent quantity of contraction—tonus or spasm—to take effect upon. Against a background of maintained contraction effects otherwise invisible, because in the nature of inhibition and therefore finding expression as relaxation, become visible. It seems likely enough that even when transection is infrabulbar, and therefore when merely spinal mechanisms remain in force, the same nexus obtains but that then, since that background of maintained contraction is lacking, the play of inhibitions remains invisible, never coming within the field of ordinary methods of observation.

When the rigidity is developed after ablation of one cerebral hemisphere only, besides the extensor spasm on the uncrossed side there is usually some flexion on the crossed side, and this especially, I think, when the cortex is inexcitable, owing to anæmia, etc. In connection with this I would add that, in conformity with results in the dog recently reported by Wertheimer and Lepage, I have in examining in repeated experiments the movements obtainable from the *homonymous* limbs by excitation of the cerebral cortex never seen flexion of the limbs but always extension, whereas from the crossed limbs it is easy, as is well-known, to obtain both flexion and extension, separately.

The results arrived at in the above communication can be shortly summarised thus :—

"Decerebrate rigidity" is but a type of extensor spasm of which allied examples follow various other lesions of the cerebello-cerebral region.

The development of "decerebrate rigidity" in a limb is largely determined by centripetal impulses coming from the limb in question.

The contraction of the muscles active in "decerebrate rigidity" can be readily inhibited by stimulation of various regions of the central nervous system, and, among others, of the sensori-motor region of the cerebral cortex.

The activity of the rigid muscles can be readily inhibited by stimulation of various peripheral nerves, and, among others, of the afferent nerve-fibres proceeding from skeletal muscles.

Reflexes obtained from the decerebrate animal exhibit contraction in one muscle-group accompanied by relaxation, inhibition, in the antagonistic muscle group ("reciprocal innervation"), and this in such distribution and sequence as to couple diagonal limbs in harmonious movements of similar direction.