Physiology. — *On the Physiology of Reflex-Standing.* By Dr. G. G. J. RADEMAKER. (Communicated by Prof. R. MAGNUS).

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When a few years ago an examination was started about the functions of the cerebellum, the relative literature was, of course, consulted. According to LUCIANI decerebellated animals display astasia, although they are able to stand, which is somewhat a contradictio in terminis. Also according to BECHTEREW these animals display disturbances of standing: "astasia consequent on a disturbance of static co-ordination".

Now we had to ask the question: what do the decerebellated animals lack for standing; from this question two others arose, viz. what is required for standing, and how is normal standing brought about.

These questions seem to me to be of great importance also for the clinic. When still attending patients in the clinic I asked myself how is it that when a patient lying on his back is examined for the tonus of the leg-muscles by grasping the leg above the ankle and flexing it passively, this flexure can rather easily be effected, even when the leg-muscles are hypertonic, whereas a standing normal person tolerates a heavy pressure upon the shoulders, without any flexion of the legs. The legs of standing dock-workers can carry from 200 to 300 kg. plus the weight of the trunk. This is more or less a mechanical action, not exclusively a voluntary one, and is performed unreflectingly.

Therefore, the recent manuals of Physiology (a.o. that of STARLING) and of Neurology were consulted on the subject of standing, but next to nothing was found about it, in the Manuals of Neurology only the familiar pictures of disturbances of standing and of the efforts to get up from a lying position in cases of progressive muscular dystrophia.

In other, especially in the older text-books of Physiology, we find laborious treatises on the standing postures, on the position of the joints in a standing attitude, on the course of the lines of gravity, and on the function of the bones, ligaments and tendons. In these treatises the muscles are altogether ignored. This is because the writers thought that muscular exercise always brought fatigue. Standing for hours being possible without great fatigue, an operation of the muscles was considered out of question.

It was especially DUCHENNE DE BOULOGNE who pointed out that the muscles play a significant part in standing, as with paralysis, or disease of the muscles standing is hampered very much, even often rendered impossible. He also maintained that in the normal standing attitudes all

the leg-muscles, extensors as well as flexors, and abductors as well as adductors, feel hard and stretched.

In 1896 SHERRINGTON reported that when an animal had been decerebrated, (i.e. when the mesencephalon had been severed transversely between the anterior and the posterior corpora quadrigemina, consequently caudal to the red nuclei), it was quite rigid, and that when the rigid animal was put on its legs, the legs could support the trunk, which the leg of the spinal animal cannot. According to SHERRINGTON the decerebrated animal can stand, it exhibits, in contradistinction to the spinal animal "standing-reflexes", consequently "reflex-standing" and possesses static tonus.

Formerly it had already been demonstrated by FLOURENS, MAGENDIE, and others, notably by GOLTZ, that also thalamus-animals can stand and, it would seem, with a normal distribution of tonus. So the thalamus-animal also displays a reflex-standing, but much more normal. MAGNUS pointed out that the posture of decerebrated animals, with the maximally stretched joints of the legs and the excessive extensortonus, is a grotesque posture.

On investigation the "reflex-standing" of a decerebrated animal exhibits such numerous and pronounced deviations, that the question rises whether it may in strictness be called standing.

I. In the first place the distribution of tonus is quite different. Not only that in decerebrated animals the extensor tonus is abnormal, but also that the flexors lack tonus altogether or nearly, while with normal standing posture, as we have already seen, *all* the leg-muscles are contracted. SHERRINGTON maintains that the standing attitude is chiefly brought about by the extensors, which according to him are the "antigravity", the muscles counteracting the gravity. That this is not always quite true, can be stated for animals as for men. When the forelegs of a dog are slightly retro-flexed, the triceps brachii feels quite flaccid. In posture with trunk bent forward the rectus femoris in man is soft, while the patella can be easily moved to and fro. Furthermore standing, as well with stretched as with semi-flexed legs is possible when the quadriceps are entirely paralyzed on either side. The literature contains records of several cases in which this was observed.

II. Another disturbance displayed by the decerebrated animal is that it does not put its legs in the right position for standing. When the animal is held freely in the air by head and tail, and is then let down till the toes touch the floor, the legs are in a wrong attitude, they rest on the dorsal side of the toes, and the animal does not put them in the right position. When the animal is lowered still more, the legs will slip backward, and finally they will be retroflexed under the body.

III. If we put the legs in the proper position, and then move the animal to and fro antero-posteriorly or sideways, it does not shift the legs; the legs do not make correcting-movements. Also when putting the legs passively in an abnormal position, there is no trace of correction noticeable,

i.e. the animal does not lift up its leg to put it down in the right position. (When flexed passively the toes recoil to the stretched-position on being let loose.)

IV. If we do not help the standing animal sideways, it overturns on the slightest push, or the slightest movement it makes, without any active efforts to prevent it, and it remains lying on its side. The righting-function, the capacity of keeping and resuming the erect position, is totally absent. (Of MAGNUS's righting reflexes only the neck righting reflexes are still present).

V. The legs of the decerebrated animals are not only strong in a standing position : they not only show extensor-tonus when the animal is "standing" but also when it is put in side- or dorsal position.

With dorsal position the extensor-tonus is often even stronger under the influence of the tonic labyrinthine reflexes. The extensor-tonus, therefore, is not caused by standing : it is not brought about by static relations. According to LIDDELL and SHERRINGTON in the standing of decerebrated animals myotatic reflexes come into play, i.e. reflexes evoked by stretching of the muscles consequent on the weight of the body. These myotatic reflexes, however, cannot be the cause of the extensor-tonus in the lateral position of the decerebrated animal.

VI. And lastly the decerebrated animal placed on a board inclining towards one of the sides, does not exhibit any changes in the distribution of tonus ; the position of the legs is not adjusted to the static relations.

The so-called static tonus of decerebrated animals, therefore, is neither evoked by the static relations, nor does it accommodate itself to the static relations ; it is even mostly more pronounced in the dorsal position.

The decerebrated animal stands more or less like a toy-animal on four stiff pillars. Of course, this comparison also halts : as the tonus of the leg-muscles varies with the change of the head-position, on labyrinth-stimuli etc.

What are the requirements for normal standing ?

In the first place that the legs should be placed in the proper position. This may be effected by two sorts of stimuli :

First by optic stimuli,

Secondly by stimuli of different areas of the body surface.

The influence of the optic stimuli can be seen, when we hold an animal freely in the air, and then approach the head to the edge of a table. As soon as the head is at a short distance from it, the animal put down its legs. This as the head is at a short distance from it, the animal puts down its legs. This these stimuli also play an important rôle in men is evident from the behaviour of tabetici with open and closed eyes. The action of stimuli emanating from the body-surface may be seen when a blindfolded animal is suspended in the air, and the lower jaw is then brought in contact with a tableboard. The forelegs are placed directly beside the muzzle, then they are stretched and the animal is supported by them. Also when the dorsal

side of the leg touches a board, the legs will be placed in a normal position on the board. Likewise pads of the hindlegs will be placed on the board when the point of the tail touches them.

These "placing-reflexes" consequent on contact are "conditioned reflexes" in PAWLOW's acceptation. If the dog is held up free in the air, with the head upward, and then the tail is touched by the hand, the hindlegs will also be stretched, but subsequently become flexed again, because the pads do not touch the board. If we repeat this five or six times, thus fooling the animal, no stretching comes forth any more. The reflex consequent on touching of the tail may be evoked again by lowering the animal a couple of times, so as to make the tail and subsequently the hindlegs touch the board. This property of being "conditioned" suggests, that we have to do here with cerebrum-reflexes. Two facts are in perfect harmony with this, viz. in thalamus-animals and also in decerebrated animals these reflexes are absent, and secondly blindfolded dogs with unilateral extirpation of the cerebrum put down only the legs of the side of the extirpation, while the contralateral legs remain hanging in the air. The unilateral absence of these reactions becomes evident also when these animals are placed on a grating and the legs are pulled between the bars. Then the legs on the side of the extirpation are placed directly on the bars, the contralateral ones retain their position between the bars. On the contrary blindfolded decerebellated animals place their legs in the right way on touching a floor, and place them also correctly on the bars of the trellis, anyhow some time after the extirpation. The first week or weeks they also often show disturbances.

As regards man, first of all we know, that in nurslings the reactions are lacking in the first half year. If we bring the posterior part of their body in contact with the floor they do not put their legs down in the right way, they lift them up. Every neurologist knows that these reactions can also be absent in pathological conditions.

In the second place an adequate supporting tonus is required for standing.

If a normal or a decerebellated animal is placed in a dorsal position, or is held up free in the air, the legs present a posture, and a distribution of tonus--relation quite unfit for standing. The legs are then more or less flexed and the resistance against passive flexion is in that case only slight. If, however, the animal is put on its legs, they are stretched at once and have changed into firm pillars that can hardly be bent. The legs then exhibit a very marked "supporting-tonus". All the muscles are protruding, and flexors as well as extensors, abductors as well as adductors feel hard and tight. The term supporting-tonus was chosen to distinguish it from the so-called static tonus of the decerebrated animals.

The following four factors play a rôle in the origin of the supporting tonus.

I. *The position of the distal parts of the extremities:* at the forelegs the position of wrist and fingers, at the hindlegs that of the toes.

We have seen already in what way the hands and the feet were placed in the right position. This change of position elicits numerous reflex-contractions, e.g. with extension of wrist and fingers reflex-contractions of the muscles of the upper arm, shoulder and shoulderblade appear, by which elbow and shoulder are extended and are fixed in this position. This fixation continues so long as the wrist is stretched passively. Likewise stretching of the toes of the hindlegs engenders extension of hip and knee, whereas with flexion of the toes the resistance against passive flexion of these joints disappears, and often reflex bending of knee and trip appears, (positive and negative supporting reactions).

These reflex-contractions can readily be felt. They were, moreover, demonstrated by SCHOEN at muscles detached from their insertions (at a so-called Sherrington-preparation).

These reactions are effected by proprioceptive stimuli. With passive extension of the wrist, fingers and toes the flexors are stretched, by which stimuli are elicited in these muscles, which by way of the central nervous system contract the other muscles of fore-, resp. hindleg.

It is quite in keeping with the proprioceptive character of these reactions, that they are still present in legs anaesthetized by severing the cutaneous nerves, and that on the contrary they disappear after severing the posterior roots of the spinal cord. After transverse section of the spinal cord extension of the wrist still produces some extension of the proximal joints, but this stretched posture is not fixed tonically. Also with decerebrated animals these reactions exhibit anomalies; with passive flexion of the distal joints fixation does not disappear completely, as the legs will still retain a distinct rigidity, a distinct resistance against passive flexion. The positive supporting reaction, of course, cannot be ascertained from the stretched, stiff legs. With thalamus animals the positive, and the negative supporting reactions are normal, with decerebellated animals they are excessively marked. Also in men similar mechanisms are operating. The nurses of the Salpétrière in CHARCOT's time had already observed that extensor cramps of the legs ceased when the toes were flexed with force. Afterwards this influence of flexion of the toes on the extensor tonus in cases of hemi-, and paraplegia, and with tranverse myelitis was described by PIERRE MARIE and FOIX as "phénomène des raccourcisseurs". It is known that when the foot is moved dorsad, it also yields reflex changes of the tonus distribution. I need only to remind the reader of the fact that it often evokes foot-clonus.

II. Secondly *touching the footsole* plays a rôle in evoking the supporting tonus.

A normal dog or a decerebellated dog in dorsal position keeps its hindlegs flexed. Now if we touch the dorsal side of the foot, the flexed position persists. If, however, we touch the sole, the leg is stretched at once to its full length, and is fixed in this stretched position. Then all the muscles

are contracted, protrude and feel hard. The ankle, knee and hip-joint are also entirely fixed. The pelvis follows every passive movement of the upperleg. If we touch the sole of the flexed hindleg and draw the touching finger back, the leg will follow as if attracted by magnetic force. For this reason this touching reaction i.e. a reaction to exteroceptive stimuli was baptized magnet-reaction. The forelegs also show this reaction; they are stretched when the sole is touched, and elbow, shoulder, nay even the shoulderblade are completely fixed. Not only all the muscles of the extremities exhibit reflex-contraction, also the muscles of the back, and, under certain circumstances also the cervical muscles. This influence on the muscles of the back and the neck is also demonstrable with dorsal position.

The contractions caused by touching the sole are *tonic*, they persist all the time the touching continues.

Of course, there is no magnet-reaction in anaesthetized legs, it is an exteroceptive reaction; nor is there any after severance of the posterior roots of the spinal cord. After transverse section of the spinal cord it is also absent, anyhow touching the soles does not give tonic contractions, which persist so long as the touching continues. (With spinal animals touching of the sole often results in a short stretching followed by flexion, the so-called extensor-thrust of SHERRINGTON.) It was observed that neither with decerebrated animals, nor with thalamus-animals touching of the soles was followed by the magnet-reaction; it was remarkable, however, that after unilateral extirpation of the cerebrum, a tonic stretching appeared when the soles were touched, as well at the homolateral as at the contralateral paws.

In decerebellated animals magnet-reaction is ever extremely vivid and yields almost maximal extension and fixation. Also the muscles of the back react excessively in decerebellated animals on the touching of the sole, and the concave back of the dog held up free in the air by the head and the tail, is not as with the normal dog bent straight but arched.

Man has not yet been examined systematically for the existence of magnet-reaction. We do know that in normal adults touching of the soles is not followed by a stretching of the leg, and also that in nurslings of 1—6 months no stretching or supporting tonus appears when the soles are brought in contact with the floor. I regret to say that I have not yet been in a position to ascertain the consequences of contact of the soles in children that have just learned to stand or walk. If we touch the hollow of the hand of a young child, a "clinging reflex" appears just as with monkeys. In pathological conditions this reflex also occurs in adults a.o. often in cases of dementia. These patients appear to me just fit subjects to observe the consequences of the touching of the soles, just as patients with cerebellar atrophy, because in decerebellated animals the magnet-reaction is particularly vivid and unrestrained.

Thirdly *pressure on the soles* also plays a rôle in evoking the supporting tonus.

This pressure will act first of all as exteroceptive stimuli, as the magnet-reaction ; only the intensity of the exteroceptive stimuli is in this case greater. However, pressure also exerts an influence on the anaesthetized paw. If the terminals of the paws are first brought in a standing position. and subsequently pressed on the sole, this pressure on the sole will intensify the stretching of the flexors of fingers, wrist and toes and the same reactions will appear as with passive placing of the terminals in the position as with the standing animal. The reactions, however, will be stronger. The result will be stretching in all the joints and still stronger fixation of the stretched position of the limb.

If the limb is already quite stretched the pressure on the sole will stretch besides the named flexors, also the extensors of elbow and shoulder, resp. of ankle, knee and hip, and through the stretching of these muscles not only these, but also others will show reflex contractions. So SCHOEN demonstrated that on the stretching of the m. triceps bracchii not only the triceps itself reacted with a contraction, but a.o. also the biceps and the supraspinatus.

In the standing animal a counterpressure is exerted on the soles equal to the bodyweight. Now, if the back is loaded, the counterpressure increases, so that all the above-named muscles will be stretched still more and hereby bring about still stronger reflex-contractions. LIDDELL and SHERRINGTON demonstrated that the reflex-contractions, evoked by stretching, will be stronger, first of all according as the stretching is more intense, and secondly as the incipient tension of the muscles is larger. In this way the adaptation to the loaded weight is effected.

The pressure on the soles also augments the tension of the muscles of the vertebral column, and, under certain circumstances, also of the cervical muscles.

In man this influence on the dorsal spinal muscles is also noticeable, notably when palpating the m. sacrolumbales, while standing alternately on the left and right leg.

After transverse section of the spinal cord pressure on the soles gives neither stretching nor a tonic contraction of the muscles. In decerebrated animals pressure on the sole causes tonic contraction only of extensors ; the flexors do not react. In thalamus animals pressure on the soles produced a tightening of flexors and extensors, but the fixation of the hindlegs most often did not become so strong as in normal or decerebellated dogs. In the latter fixation of the joints is very much intensified by pressure.

If a normal or a decerebellated dog is placed with one leg on a balance, it appears that the hindleg can bear a counterpressure of 1½ times the bodyweight, the foreleg even more than double that weight, without flexing.

IV. Finally *the mutual influence of the positions of the proximal joints* come into play.

If one of the proximal points, elbow or shoulder, resp. knee or hip, is stretched passively or actively, other joints will also stretch and are fixed

in stretched position. If e.g. of a dog the upperarm is moved forward, the wrist and the elbow will also be stretched and these joints cannot be flexed passively in that case. Conversely, passive flexion of one of the proximal joints is attended with flexion of the other joints and fixation in flexed position. With passively flexed shoulder, elbow and wrist cannot be stretched completely.

This mutual influence is principally, perhaps entirely, attributable to the anatomic relations. Reflex influences of one muscle on the other are not distinctly observable. The appearance of this phenomenon depends, however, on an adequate tonus of the muscles. In spinal dogs it is still present ; stretching of a proximal joint is still attended with stretching of others, mostly, however, with smaller fixation. On the other hand, it is no longer observed in maximal, deep narcosis, or only concomitant stretching occurs without fixation. This mutual influence of the joints is answerable for the fact that a fully stretched leg is more difficult to flex than a semi-flexed one.

In the foregoing we discussed :

1°. how the legs are placed in the proper position for standing ;

2°. in what way the supporting tonus is evoked ; and

3°. how the supporting tonus is adapted to the loading.

It still remains for us to ascertain what factors play a rôle in the adaptation to the static relations, to the changes of the plane of the floor. Only the principal factors will be discussed briefly :

I. *The position of the head.*

If we place a normal (or better still a decerebellated) dog in dorsal position and hold the muzzle vertically upwards or ventral, the hindlegs will, on touching the soles, display a marked magnet reaction, and pressure on the soles is also followed by the occurrence of intense stretching and a strong resistance against passive flexion. If, now, while pressing the soles we move the head in dorsal direction, we feel the resistance slacken and ultimately disappear when the muzzle sinks below the horizontal. Then the hindlegs will twitch and neither touching nor pressure on the sole will evoke a stretching any more. Also in the standing animal this influence of the position of the head and neck on the supporting tonus of the hindlegs, is evident. With a posteriorly upward position of the head the supporting tonus of the hindlegs is weak, and it is strong with ventral flexion of the head and the neck. Also the supporting tonus of the forelegs changes in this process, but in an opposite sense. When raising the head it increases, with lowering of the head it decreases.

This influence of the position of the head, caused by the tonic neck-reflexes of MAGNUS and DE KLEYN can promote the adaptation of the muscle-tonus and of the position of the limbs to the inclination of the floor. For if an animal stands on a board or table, which is moved up and down at the front or at the back, then the position of the head in space. is altered. Thereby the labyrinthine righting reflexes will begin to operate

and the head will be brought back again to the original position in space.

If e.g. the top of the table is moved down, the labyrinthine righting reflexes will move the head backward, by which the supporting tonus of the hindlegs will decrease, that of the forelegs will increase. Consequently the former will flex, the latter will stretch. Labyrinth-stimuli are not indispensable to this adaptation, as labyrinthless dogs, also when they are blindfolded, also exhibit this altered position. It follows that other factors must be in operation. (Labyrinthless dogs, however, exhibit a proper adaptation only when the up-and-down movement of the table takes place slowly. For if the top of the table is moved up quickly, we shall see that on account of the absence of the semi-circular canal reactions the labyrinthless animals will turn a somersault backward and will be dashed to the ground.)

II. *The bending of the back.*

We have seen that touching the soles as well as applying a pressure on the soles influences the bending of the back and the tension of the dorsal muscles. Conversely also the bending of the back plays an influence on the supporting tonus of the legs. If the back is convex the supporting tonus of the hindlegs is strong ; if concave it is weak, and the hindlegs are twitching. This influence emanating from the back begins to operate with the adaptation to the static relations, if only the position of the bearing surface of the hindlegs changes, while that of the forelegs remains constant.

Also with men the bending of the back has a similar influence. Every one who happens to have been engaged in a wrestling-match, knows that as soon as he has succeeded in slightly twitching the back in the loins, it is an easy thing to flex the legs completely.

III. *The influence of the position of the forelegs on the supporting tonus of the hindlegs.*

If a dog is placed with its forelegs on a steady bearing surface, e.g. on the edge of a table, while the pads of the hindlegs rest on the hand, and if the trunk is moved backward, so that the forelegs are moved forward in the shoulders, we shall feel that the hindlegs are being stretched immediately and push the hand back with great force. This stretching attended with a strong resistance against passive flexion persists so long as the position of the animal is not altered. If, on the contrary, the trunk is moved forward, by which the forelegs go back in the shoulders, we shall feel the resistance decrease, and ultimately the hindlegs are twitched.

With dorsal position the same occurs. If you place one hand on the pads of the forelegs of the supine animal, and the other hand on the pads of the hindlegs, you'll also observe that with passive forward movement of the forelegs a stretching and an increase of the supporting tonus of the hindlegs occurs, and with a backward movement of the forelegs a decrease of the supporting tonus.

The significance of this influence for the adaptation to the static relations

in standing on a bearing surface, that is moved up-and-down at the fore-part or at the back, is self evident.

IV. *The influence of the position of the contralateral leg.*

If a dog is placed with one of his legs, say the right foreleg, on a table, while the contralateral leg, in casu the left one, rests on the hand, we feel that with sideway to-and-fro movement of the trunk the supported leg is flexed and stretched. With a movement of the trunk towards the left a stretching of the supported left foreleg occurs together with strong resistance against passive flexion, with a movement of the trunk to the right disappearance of the resistance and flexion of the leg. On closer investigation it appeared that this altered tonus was caused by the ab- and adduction of the right foreleg. For, if instead of the trunk the board on which the right foreleg rested, was moved to and fro, the reactions of the left foreleg occurred all the same. Also when the dog stands on one *hind*leg sideway to and fro movement of the trunk causes the other hindleg to exhibit alternately flexing and stretching movements.

A movement of the trunk antero-posteriorly yields similar reactions. If e.g. the animal stands on the right foreleg and if the trunk is moved forward, a forward stretching and likewise a strong resistance against passive flexion of the supported left foreleg will take place; when the trunk is moved in the opposite direction again, the resistance will disappear again and flexion of this leg will follow.

Also in the animal in dorsal position similar reactions can be elicited.

All the reactions discussed sub I—IV are tonic. They occur in normal, as well as in thalamus animals. In decerebellated dogs they appear very automatically, and cause excessively marked changes of the supporting tonus.

V. *The influence of the position of the leg in shoulder, resp. hip-joint on the supporting tonus of this leg.*

If we place a dog with one leg, say the right foreleg, on a table and place this leg in strong abduction, it will show but little supporting tonus ; the muscles of fore- and upper-arm feel flaccid, the elbow is partly flexed and the leg yields even to very light pressure. If now we move the trunk dextrad, so that the leg is charged more heavily, and the markedly stretched adductors relax at the same time that the abductors become stretched, then the elbow and the shoulder will be seen to extend. The muscles of the leg now feel compact and pressure on the shoulder meets with strong resistance. The nearer the leg approaches the median position, the stronger the resistance of the leg will be, the stronger the supporting tonus will become.

Similar reactions will occur when the bearing surface of a straddle-legged animal is moved down at one of the sides, say, at the right side. Gravitation will then draw the trunk to the right and try to adduct the right legs.

If a leg, say the right-foreleg, stands in the median position, and the trunk

is moved dextrad, while the toes are fixed with one hand on the bearing surface, so that the leg is adducted, the leg will twitch at once under the weight of the trunk, and all the supporting tonus disappears. This disappearance of the supporting tonus is part of a correcting-movement, for if the toes are not fixed on the table and the trunk is moved dextrad, it will be seen that at the moment the supporting tonus disappears the leg is raised, subsequently abducted, and placed more outwardly. This reaction is probably caused by the intense stretching of the abductors, and is very likely a proprioceptive correcting-movement. Quite conformable correcting movements occur, when by removing the trunk the leg is transposed from the median position in the shoulder, resp. hip, posteriorly, anteriorly or exteriorly. Besides for the adaptation to the static relations and to the recovery of the body-equilibrium, these reactions are important also in other respects. For these reactions explain the puzzling phenomenon in thalamus-animals that, although they lack the placing-reflexes and correcting-movements on stimuli emanating from the body-surface, they always place their legs in the proper way in standing, walking and falling. These reactions are lacking in decerebrated animals. In thalamus-animals they are as a rule always present, but sometimes they occur somewhat late. They are often absent in decerebellated animals shortly after the extirpation; afterwards they always come back but display typical deviations. First of all they appear too late i.e. only when as with normal dogs, the leg is transposed further posteriorly, interiorly or exteriorly, and secondly the movement is too strong, too large, the leg is raised too much, is put down too far and too forcibly and with too loud a rap.

If we place the decerebellated animal with one foreleg at one end of a board and move the trunk anteriorly, the animal will halt along to the other end with fewer paces than a normal dog.

If an animal stands on a board, that is being moved down at the one end, gravitation will pull the animal forward. The animal then adapts itself to the static relations, and shows resistance by stretching the forelegs, while the hindlegs flex. If you pull a thalamus dog standing on a horizontal board, forward, you'll also see, no matter whether you pull at its head, neck, chest- or back-skin, that the forelegs are stretched forward, and that the hindlegs are flexed.

By pulling the animal forward first of all a heavier weight presses upon the forelegs and secondly the flexors of the metacarpophalangeal joint and the wrist, and also the extensors of elbow and shoulder are passively stretched. If the animal stands on a board that is moved down on the rightside, gravitation will draw the animal dextrad. It adapts itself by resisting outwardly, i.e. by stretching and abduction of the right legs, while the left legs will flex. Quite the same reactions of the legs appear when a normal, thalamus-, or decerebellated dog standing on a horizontal board, is pulled or pushed by the skin to the right. This pulling causes the

right legs to be more heavily charged and the abductors of the right shoulder and hip are passively stretched.

The appearance of these reactions depends only on the direction of the force, not on the point of application.

Still, the latter must have some influence, as is evident from thalamus dogs. If you take a thalamus dog by the head without pulling, the animal will try to get free by pulling backwards; if, however, you take him by the tail the animal will get free by pulling forwards. If you take him by the right ear, the animal will turn his head to the left or walks round in circles to the left, right against the hands of the clock. If, on the contrary you hang a clamp at the skin of chest or hip of the right side, the animal will walk to the right.

All the above-described reactions, coming into play with standing and with adaptation to the charging and to the static relations, disappear after severing the posterior-roots, while the reactions on exteroceptive stimuli, such as magnet-reaction, disappear already after cutting the cutaneous nerves.

Regarding the localization of the centra of these reactions we saw already :

I. That after transverse section of the spinal cord most of these reactions are lacking, whereas others are considerably disturbed (touching the sole sometimes gives a brief stretching, pressure on the sole a brief fixation), so that standing is out of the question.

II. That also after decerebration most of these reactions are absent, while the others exhibit considerable disturbances also now.

III. That in thalamus-animals all the reactions are present, except the proper placing of the legs on optic stimuli and on stimuli emanating from the body-surface and also excepting the magnet-reactions.

IV. That after unilateral extirpation of the cerebrum the placing-reflexes on stimuli emanating from the body-surface, are absent at the legs on the side of the intact half of the cerebrum, that the other reactions, also the magnet-reactions occur, as well at the homolateral as at the contralateral legs.

V. That in decerebellated animals all the reactions are present, most of them even excessively. (This holds good only when the animals have accommodated themselves as well as possible, i.e. 3—6 months after the extirpation. On the first days after the extirpation most of these reactions do not appear and after this they are still disturbed for some time.)

In decerebellated animals some of these reactions are merely exclusively excessive, hypermetric ; so e.g. the hypermetrical stretching and fixation of the extremities and the excessive bending of the back on touching the soles. Nothing was noted of too long a latency. With other reactions, on the contrary, as with proprioceptive correcting movements the lateness as well as excessiveness was observed. That these disturbances of the static reactions will contribute to the appearance of the so-called cerebellar ataxy, is evident.

In man standing is disturbed or quite impossible in cases of serious tabes (affections of the posterior roots and horns), of serious poliomyelitis

	Spinal animal	Decerebrated animal	Thalamus-animal	Decerebellated animal
Placing-reflexes	—	—	—	+
Magnet-reaction	—	—	—?	+, excessive
Pos. supporting reaction	disturbed	disturbed	+	+ „
Neg. supporting reaction	—	disturbed	+	+ „
"Wiebel reactions" [1]	—	disturbed	+	+ „
Proprioceptive correcting movements	—	—	+	+ „
Other adaptation reactions	—	—	+	+ „
Neck righting reflexes	—	+	+	+
Other „ reflexes	—	—	+	+

(affections of the anterior horns) of serious neuritis caused by lues, beriberi etc., and in cases of muscular dystrophia, so in general with interruption of the spinal reflex arc. Then again with transverse lesions of the spinal cord, quite in keeping with the observations on animals. RIDDOCH and LHERMITTE observed in wounded soldiers also that the other phenomena after total transverse lesions of the spinal cord in man resemble completely those displayed by animals, while also after transverse lesions of the mesencephalon decerebrate rigidity occurs in man with a similar symptomatic aspect. With these, and also with other affections characterized by strong rigidity, as e.g. with serious spastic spinalparalysis, standing is disturbed in man. Standing is further impossible in man in diseases with still unknown localisations, as in cases of chorea mollis, athetose double, and others, finally also in nurslings.

The clinical examination of the muscle tonus is generally performed in dorsal position of the patient. Therefore, also the supporting tonus in animals was examined while the animal was lying on its back. It then appeared, that with normal animals in dorsal position pressure on the soles yielded far less supporting tonus than with the standing animal. This difference was much less in decerebellated animals. The following observations are especially remarkable. They were made in a dog of which the right half of the cerebellum had been extirpated, in the stadium in which the animal was able to stand again unsupported.

We see from following table :

firstly : that when the animal stands on one of the hindlegs the hindleg on the side of the extirpation had a weaker supporting tonus ;

[1] Reactions emanating from the contralateral limb.

Dog Fox ($6^1/_2$ kg.)
1 month after extirpation of the *right* half of the cerebellum.

Strength of the supporting tonus in kilogrammes

	Right hindleg		Left hindleg	
Standing on one leg	+ $6^1/_2$	− $7^1/_2$	+ 8	− 9
In dorsal position	+ 7	− $7^1/_2$	+ $2^1/_2$	− 3

secondly : that the supporting tonus of this leg was as strong with dorsal position as with standing ;

thirdly : that the supporting tonus of the contralateral leg was much weaker in dorsal position than in standing, so that with dorsal position the supporting tonus of the homolateral leg was stronger than that of the contralateral one.

On closer inspection we observed that this decrease of the supporting tonus of the contralateral leg was caused by the pressure on the back. This pressure mostly produces a distinct decrease in normal dogs, much less in decerebellated dogs, whereas in decerebrated animals the rigidity often increases in dorsal position under the influence of labyrinthine stimuli.

Also by other stimuli on the back the supporting tonus decreases as, e.g. taking hold of the dog with two hands by the skin of his back. This decrease also occurs with thalamusdogs.

If a patient lying in bed on his back is examined, the abdominal wall will tighten when palpation takes place. The patient is then told to keep calm, not to obstruct, so that then the tightening most often ceases. The reflex of the abdominal wall is then inhibited voluntarily, psychically. Quite similar phenomena are observable when investigating the tonus of the muscles of the extrimities, as well in man as in animal.

If you speak gruffly to a dog that is being examined, the supporting tonus often disappears directly and neither touching nor pressure is of any influence. Every one knows that a dog's legs twitch abruptly when you speak to it gruffly.

CONCLUSIONS.

I. Normal standing is brought about by a number of extero-, and proprioceptive reactions and the centra of these reactions are situated in different parts of the central nervous system.

II. All these reactions occur (most of them excessively) in decerebellated animals, and probably part of the aspect of the "cerebellar ataxy" depends on the excessiveness of these reactions.

III. Tonus and supporting tonus should be sharply differentiated, as in man and in animal hypertonia is often attended with a decreased supporting

tonus ; e.g. the hemiplegic leg shows most often less supporting tonus than the healthy one.

IV. Touching of the sole is alone competent to alter the muscle-tonus of the whole body of an animal, a precise investigation of the muscle-tonus is, therefore, very difficult, and the description of this investigation should always be accompanied by a minute report of the circumstances under which it took place.

V. In the clinic the examination of the muscle-tonus occurs mostly with dorsal position of the patient. In animals this position (apart from the occurrence of labyrinthine stimuli) inhibits certain reflexes that increase the muscle tonus.

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