THE JOURNAL OF NEUROLOGY AND PSYCHOPATHOLOGY.

Vol. V.

FEBRUARY, 1925.

No. 20.

Original Papers.

ON A CASE OF ORGANIC SPINAL HEMIAN- ÆSTHESIA SHOWING THE PERSISTENCE OF A PECULIAR FORM OF SENSATION AND THE OCCURRENCE OF PHENOMENA OF ALLO- ÆSTHESIA AND HETERÆSTHESIA.

By R. M. STEWART, LEAVESDEN.

THE study of the centripetal paths of the spinal cord may be said to have received its greatest impetus in 1846, when Brown-Séquard¹ published his historic account of the paralysis which has ever since borne his name. He showed that division of one-half of the spinal cord is followed by motor disturbance on the side of the lesion and a disturbance of certain forms of sensibility on the opposite side of the body, and although he was subsequently led to abandon his theory of the decussation of sensory paths the accuracy of his original observations has been fully established by the work of recent years. As is now well known, the nerve impulses for the different forms of sensation travel in tracts of the spinal cord, some of which are crossed and some uncrossed. It follows, therefore, that a clean-cut lesion which involves the whole of one lateral half of the spinal cord does not abolish all sensations from the opposite half of the body, but does give disturbances of sensation on both sides of the body. It does not effect a complete hemianæsthesia, yet it is theoretically possible for this to occur. A complete double hemianæsthesia occurs, of course, when the spinal cord is completely severed, but hemianæsthesia confined strictly to one side of the body can only occur when all the afferent tracts which convey the impulses from that side of the body are severed, and these only.

It can only occur if these conditions are fulfilled, and no single afferent fibre in the cord conveys impulses upward from both sides of the body. The necessary lesion must be one which affects part only of each lateral half of the spinal cord, and the parts affected must be dissimilar on the two sides, and in a manner complementary. Naturally such a selective lesion is rare where accident brings about the injury. If it should occur we would expect to find no disturbance of sensibility on one side of the body (which may or may not show disorder of voluntary movement), but on the other side we would expect to find very grave disturbances. Kinæsthetic sensations (evoked by active or passive movements of the limbs); the 'sense' of vibration; the sensations by which the size, form and weight of an object are recognized; the sensations whereby the number of synchronous contacts on the skin is recognized; the sensations whereby the locus of the contact is recognized; the sensation of touch; the sensation of pain, whether superficial or deep; the sensations of heat or cold, whether of small or great degree—all should be abolished by interruption of the conducting paths which convey the impulses which subtend them. In these circumstances a peripheral stimulus would be stripped of all its peculiar qualities, and the question arises: If each of these elements is carefully investigated and found to be absent, does anything at all remain? That is, may there on the one hand be absolute anæsthesia, so that the subject cannot exhibit by his reactions any knowledge at all of having been stimulated; or, on the other hand, may some indefinite sensation persist, so that the subject can say accurately when he has been stimulated, but yet can give no other information at all with regard to the qualities of the stimulus? Such a problem can only be investigated in a subject who accurately presents the symptom complex of complete spinal hemianæsthesia, and it is the purpose of the present communication to record the clinical features of a case of this kind which came under the care of Professor T. Graham Brown and the writer during the late war.

SYNOPSIS OF THE CLINICAL HISTORY.

In the act of diving into shallow water a young soldier experienced a sudden pain in the neck and at once lost the power of his limbs. He was pulled out of the water by his comrades and soon regained some power in the left upper and lower limbs. During his subsequent treatment in a field ambulance, in a casualty clearing station, and in a general hospital it was observed that there was loss or impairment of voluntary movement in both limbs on the right side of the body; abolition of knee and ankle jerks on both sides (but later slight responses were obtained, save in respect of the left ankle jerk); sensory disturbance to tactile and pain stimuli on certain parts of the right upper limb, on the left upper and lower limbs, and on the whole of the left side of the body

below the level of the second rib. The right pupil was noted to be smaller than the left, and the right palpebral fissure narrowed.

On the eighteenth day, when the patient came under our care, his condition was as follows :

He was a small, well-built muscular subject and showed no signs of disease save in his nervous and osseous systems. Lateral movements of the neck were free, but movements of flexion and extension were restricted and elicited pain. The projection in the cervical region of the spinal column which was said to have been present had disappeared, and an *x*-ray photograph showed a fracture-dislocation of the fifth and sixth cervical vertebræ.

On the right side there was marked pseudoptosis, enophthalmos, and myosis ; the right pupil did not dilate on shading. The masseters, face, palate, tongue and sternomastoids were normal.

MOTOR FUNCTIONS.

Right Upper Limb.—There was complete paralysis of the latissimus dorsi, triceps, flexors of the wrist, flexors and extensors of all digits, and the intrinsic muscles of the hand ; paresis of the extensors of the wrist. The biceps and supinator longus contracted well.

Left Upper Limb.—There was no absolute paralysis, but marked paresis of the latissimus dorsi and triceps ; slight paresis of the extensors of the wrist, fingers and thumb, and intrinsic muscles of the hand. The biceps and supinator longus contracted normally.

Trunk.—The right rectus abdominis muscle was paresed ; the umbilicus deviated to the left when the patient coughed ; the diaphragm was normal.

Right Lower Limb.—There was great weakness of all voluntary movements, most pronounced at the toes and ankle, less at the knee, and least at the hip.

Left Lower Limb.—Voluntary movements were normal in extent and strength.

SENSORY FUNCTIONS.

Right Upper Limb.—Tactile sensibility was totally lost in the whole of the area supplied by the seventh and eighth cervical dorsal spinal roots, and in part of the area supplied by the first thoracic root. Comparative blunting existed in part of the areas supplied by the fifth and sixth cervical, and first, second, and third thoracic roots. Total loss to pain stimuli could be demonstrated on the dorsal aspect of the fingers and distal half of the back of the hand, and, above the wrist, partial loss, in areas which corresponded very closely with those for tactile anæsthesia. Thermal sensibility was lost on the palm and dorsum of the hand and both aspects of the fingers, while blunting existed in the territory of the first thoracic root area.

Joint sensibility was lost at all joints of the fingers and at the interphalangeal joint of the thumb.

The appreciation of the vibrations of a tuning fork was lost on all five digits, and diminished on the bones of the fore and upper arms.

Left Upper Limb.—Blunting to light touch existed in the dorsal parts of the fifth and sixth, and in parts of the seventh and eighth cervical and first thoracic root areas. Pain sensibility was completely lost in a similar distribution. Thermal sensibility was lost in the eighth cervical and first and second thoracic root areas. Joint sensibility was found to be intact. The sense of vibration was diminished in the ulna, and in the phalanges and metacarpal bones of the annularis and minimus.

REMOTE SENSORY EFFECTS.

Except in the regions of the right upper limb already described there was no sensory change upon the right side of the body at any stage of the condition. The only possible disturbance noted was a doubtful loss of the 'sense' of vibration when the tuning fork was applied to the right patella. The appreciation of movement at the various joints of the right lower limb was carefully investigated and found to be perfect. Compass tests gave apparently normal results on the right side of the body.

On the left side of the body profound sensory changes of an unusual character were found on the trunk and lower limb, the upper boundary of which corresponded to the upper border of the second rib. The patient replied to all forms of stimuli, but the sensations evoked by the different forms of stimulation were all described as similar. Tactile, pressure, thermal and pain stimuli were not recognised as such, but were described as "queer" or "funny," "like electricity" or "as making him laugh."

At this stage joint sensibility was apparently normal in the left lower limb, but the 'sense' of vibration was markedly diminished on the left side of the trunk and left lower limb. With the compass test no apparent difference could be detected on the soles of the feet, nor in the recognition of objects applied to them, but on the left side of the abdomen the power of discriminating two points of the compass was grossly impaired, and in the same locality stimuli were badly localized.

Thus far, the case had presented a rough approximation to the typical Brown-Séquard syndrome, but the lesion had not yet reached its full extent, for as time went on further changes could be demonstrated.

PROGRESS OF THE SYMPTOMS BEFORE STABILITY WAS ATTAINED.

The sensory changes in the right upper limb slowly decreased in severity (*Fig. 1*). Within seven days of admission the areas of total and partial loss to light touch disappeared in the fifth and sixth cervical

root areas, and this was followed by a partial retrogression of the extent of relative loss in the first and second thoracic root areas. Finally, the hypæsthesia was so slight that it was by no means easy to determine its boundaries, and at the end of five months the area of blunting to light touch, pain, pressure, heat and cold appeared to correspond to the distribution of the seventh and eighth cervical, and first and second

FIG. 1.—Chart of the right upper limb, showing the areas of sensory disturbance to tactile, pain and thermal stimuli on the twenty-third day.

FIG. 2.—Chart of the left upper limb, showing the areas of sensory disturbance to tactile, pain and thermal stimuli on the twenty-third day.

thoracic spinal roots. In the case of the left upper limb the changes were more marked and more rapid (*Fig. 2*), for within five weeks of the patient's admission to hospital the loss to light touch had disappeared, and at the end of two months no sensory disturbance could be detected.

The motor disturbances in the upper limbs gradually diminished in a similar manner. Five months after the accident an examination of the right upper limb showed marked paresis of the triceps, flexors of the wrist, long flexors and extensors of the digits and abductors of the thumb. Slight paresis could be demonstrated in the cervical fibres of

the trapezius, and in the latissimus dorsi. At this time motor power in the left upper limb was normal, all muscles contracting powerfully.

The paresis in the right lower limb also gradually disappeared, leaving, however, a residual degree of weakness which was very evident when comparisons with the left limb were made.

Important changes of a progressive character took place in the sensory disturbances of the left half of the trunk and left lower limb. These consisted chiefly in a gradual loss of joint sensibility. At first the patient could recognize passive movement and its direction, if the passive movement was not a very small one, but seven weeks after the accident the joint sensations in the left lower limb were found to be much impaired, although not abolished. The appreciation of weight was next

FIG. 3.—Diagram showing area (unshaded) on the sole of the left foot where at first cutaneous sensibility was only slightly impaired.

lost, and later the appreciation of the direction of passive movement although the patient could still say when a passive movement had been given. Finally, it was found that he was totally unable to distinguish a passive movement from, say, a pinprick, nor could he say at which joint it had taken place. The quality of joint sensation had entirely disappeared, and it was only by inference that he guessed that a passive movement had taken place. In other words, if told

to state when a passive movement was given he replied correctly; but if not warned that one was to be given he could not state if the stimulus was a passive movement, a pinprick or a light touch, and so on. During the course of examination an area was found on the left lower limb which included the sole of the foot, plantar surfaces of the toes, and dorsum of the hallux and second toe, where the compass tests at first appeared to be normal, and where light touch and pain stimuli appeared to give their qualities with only a slight impairment (*Fig. 3*). Finally, however, the power of discriminating two points of a compass was grossly impaired, and the qualities of sensations of different sorts became lost, although stimuli of different forms gave differences in intensity of the common sensation which was evoked.

Lastly, localization, which was at first only slightly impaired, became abolished for stimuli of all types.

The sensory functions of the right side of the trunk and right lower limb remained normal.

THE SITE AND NATURE OF THE LESION.

Although in the absence of a pathological examination the nature of the morbid process must remain a matter of speculation, it will none the less be of some interest at this stage to analyze from the pathological standpoint the early symptoms and subsequent history of the case.

The initial symptoms—immediate loss of power in all four limbs during the act of diving, together with sudden and severe pain in the neck—suggested as a possible diagnosis either hæmatomyelia or fracture-dislocation of the cervical vertebræ with injury to the spinal cord. Regarding the first of these possibilities, numerous observations have shown that forced bending of the neck, as in diving head foremost into water, is especially liable to produce hæmorrhage into the spinal cord, and in the case under consideration such a history was obtained. The patient was confident that the sudden onset of the paralysis was not related to a concussion of the head, since he did not reach the bottom of the stream. Fracture-dislocation of the cervical vertebræ may also be brought about by the act of diving and, as already mentioned, an *x*-ray photograph showed that the patient had, indeed, sustained such an injury. The presence of a fracture-dislocation of the fifth and sixth cervical vertebræ did not, however, give any precise data as to the nature of the cord injury; the presence or absence of central hæmatomyelia, of crushing, contusion, or tearing of the spinal cord and nerve roots, and the possibility of epidural and subarachnoid hæmorrhages had all to be considered. With regard to the part played by hæmorrhage it can be stated with confidence that extramedullary bleeding did not occur, at least, to any extent, for examination of the cerebrospinal fluid showed no evidence of recent admixture with blood. Greater difficulties, however, arise when the question of intraspinal hæmorrhage is raised, and the possibility of its occurrence can hardly be excluded. Indeed, it seems more than likely that the curious complex of symptoms observed owed its origin to a number of intramedullary hæmorrhages in certain localities of the cervical cord. On admission to a general hospital no obvious deformity of the cervical vertebræ could be detected, although the patient complained of severe pain in this region. If the observation that a projection was at first present on the neck be correct, subsequent reduction of the displaced vertebræ must have taken place, and it is therefore likely that some degree of contusion or crushing of the cord occurred at the moment of injury and that no permanent compression existed. The incompleteness of the motor paralysis and the very remarkable rapid restoration of power in the left upper and both lower limbs pointed to the presence of a spinal cord lesion of a far less serious character than is commonly encountered at this high level. It is usual in vertebral injuries which simultaneously

involve the cord and roots for the more delicate structure of the cord to be seriously affected, while the root symptoms are slight or even absent. In this case the relationship was reversed; profound motor paralysis was present in the distal segments of the upper limbs, distributed in root fashion, and became gradually more marked, while at the same time recovery of power was rapidly taking place in both lower limbs; this lack of agreement between the spinal and the root symptoms can only be explained on the supposition that trauma or shock exercised its effects to a greater degree on the nerve roots than on the cord itself.

VERTICAL EXTENT OF THE LESION.

The vertical extent of the lesion in the cervical cord can be determined with a fair degree of accuracy by a consideration of the distribution of the sensory and motor disturbance on the trunk and upper limbs. The integrity of the diaphragm and trapezii muscles indicated the escape of the fourth cervical segment and corresponding nerve roots; while the presence of sensory and motor disorder in the distribution of the fifth, sixth, seventh, eighth cervical, and first thoracic roots on both sides indicated involvement of all roots below this level down to and including the first thoracic nerve root.

The sensory disturbances resulting from implication of the posterior nerve roots were very extensive on both upper limbs, but were more marked and more permanent on the right side. Indeed, on the final examination no sensory loss could be detected on the left upper limb, while blunting to all forms of cutaneous stimuli and to pressure was still present on certain areas of the other limb. The injury to the posterior roots was, therefore, of a more severe form on the right side, that is, the side on which (as will be seen later) there was most damage to the spinal cord itself.

It is also important to note that while the sensory disturbances on the right upper limb did not entirely clear up, considerable improvement did occur, and from this it may be inferred that there was a relative escape of the afferent paths for these fibres through the lower cervical segments of the cord.

A consideration of the sensory phenomena showed that the 'root' anæsthesia on the left side was continuous with the 'tract' anæsthesia, and it was therefore comparatively easy to determine the level of the intraspinal lesion on the right side of the cord. It is unnecessary to refer here to the features which distinguish 'root' anæsthesia from 'spinal' or 'tract' anæsthesia, but it may be noted that the distinction was rendered more easy in this case by the discovery that the spinal anæsthesia was accompanied by a qualitative change which did not exist on the limbs. Its topographical distribution extended as high as

the level of the second rib on the left side, and consequently the lesion on the right side of the spinal cord cannot have extended below the second thoracic segment.

THE TRANSVERSE EXTENT OF THE LESION.

Throughout the clinical course of the case it was evident that the cord lesion was far from being complete. The motor loss dependent on interruption of the pyramidal tracts disappeared with unusual rapidity, and within twenty-four hours of the injury motor power in the left lower limb had completely returned. The right lower limb, at first paresed, rapidly improved, and in five weeks' time the patient was able to walk without a noticeable limp.

Apart from the paralysis dependent on root injury the motor symptoms were slight in comparison with the disturbance of sensibility. To arrive at any conception of the extent and nature of the cord injury it is necessary to review the sensory symptoms displayed at two periods; first, in the early part of the clinical course, and secondly, some months later. When examined on admission sensibility was as follows:

(1) Anæsthesia and analgesia distributed in root fashion on both upper limbs; (2) complete integrity of cutaneous and deep sensibility on the right half of the trunk, and on the right lower limb (vibration 'sense' was possibly absent on the right patella); (3) disturbance of cutaneous sensibility to light touch, pinprick, heat and cold on the left lower limb. Impairment of the appreciation of pressure-pain and pressure-touch and the vibrations of a tuning fork in the same locality. Testicular sensation was diminished on the left side. Stimuli were correctly localized, and the threshold for simultaneously applied compass points was normal. At this stage a diagrammatic representation of a cross section of the cervical cord would show (*Fig. 4*): (1) complete integrity of the left corticospinal tract and slight implication of the right corticospinal tract; (2) complete integrity of the left spinothalamic tract conveying impulses for temperature and pain sensibility from the right half of the body, and complete interruption of the right spinothalamic tract; (3) slight involvement of the left posterior columns (indicated by the partial loss of vibration 'sense' and diminution of testicular sensation) and normal right posterior columns; (4) implication of the anterior and posterior nerve roots. Thus the lesion differed from that encountered in the typical Brown-Séquard syndrome in two respects, namely, the complete absence of injury to the right posterior columns, and the slight involvement of the left posterior columns.

FIG. 4.—Shows the probable extent of the lesion in its early stage.

In the final examination further sensory changes were present. On the left side of the trunk and on the left lower limb all forms of stimuli gave rise to sensations which were indistinguishable in quality. The patient was now completely unable to appreciate the vibrations of a tuning fork or passive movements at any joint of the left lower limb, and testicular sensation was completely abolished on the left side. On the other hand, motor power was perfect on the left side, and on the normal half of the body slight alteration of the normal reflex excitability was the only indication of pyramidal involvement. To account for so complete a disturbance of all forms of sensibility on the left half of the trunk and on the left lower limb it is necessary to assume that in addition to interrupting the right spinothalamic tract the lesion had implicated all centripetal tracts running in the left posterior columns. A diagram of a cross section of the cord illustrating the extent of the

FIG. 5.—Shows the probable extent of the lesion in the cervical cord in its final form.

morbid process at this stage (*Fig. 5*) would now show a lesion of the entire posterior column on the left side. It is difficult to visualize the nature of the morbid process which could bring about such a condition, and there was nothing in the clinical history to suggest a late hæmorrhagic extravasation or ischæmic softening in this region of the cord, but it seems fairly certain that the morbid process which gave rise in the early stage to such slight evidence of posterior column involvement became more extensive as time went on, resulting finally in almost complete physiological interruption of all tracts running upwards in the left posterior column. Whether this was of the nature of a spreading gliosis or a gradual vascular and lymphatic occlusion it is impossible to say.

COMPLETE SPINAL HEMIANÆSTHESIA.

Although complete spinal hemianæsthesia of organic origin does not appear to have been previously described, it is possible that the phenomenon may have escaped observation owing to a defective manner of clinical investigation. Thus in one method of routine examination the patient is asked to state when he has been touched. He may, perhaps, give the information that tactile stimuli feel dull, and the observer then records that there is blunting to light touch. When asked to differentiate between a light touch and a pinprick the subject may state that they feel the same, or he may simply say that the pinprick is not painful. Pain is then said to be abolished, and so on. But what may really take place is that different stimuli, as such, still evoke sensation, while the special qualities associated with them may be abolished. Unless, therefore, sensory tests are conducted in such a manner as to

discriminate between the qualities of different sensations the true nature of the sensory disturbance may be missed.

As already stated, although the patient could not recognize different stimuli one from another, he was yet not completely insensitive to any one of them. The quality of different sensations had disappeared; the sensations had apparently no variation in intensity, extensity or local signature; but sensation of a peculiar form was still evoked. For convenience this condition may be termed 'archæsthesia.'

1. *The Quality of the 'Archæsthetic' Sensation.*—It was significant that the patient was quite unable to describe accurately the sensation evoked by all forms of stimuli. It appeared to him simply a "funny

FIGS. 6 AND 7.—Illustrate the belt of skin on which stimuli (in this case, cold) evoked both ordinary feeling and 'archæsthesia.' Subsequent investigation showed that line A lay rather more to the right than is seen in the illustrations.

sensation," and when pressed to describe it in more detail he replied that it was just "funny" or a "funny feeling." Once he said that it was "sort of tickly and made him laugh," but that it was also disagreeable. It seemed to have no element of touch, pain, heat or cold in it, and it had no resemblance to a visceral sensation. It was unlike the sensation given by faradism, or a vibrating tuning fork, and indeed the patient himself volunteered the statement that it was unlike anything which he had previously experienced.

2. *The Adequate Stimuli.*—All the forms of stimuli in clinical use evoked "funny feeling." When a lumbar puncture needle was thrust through the skin on the left of the midline the patient stated that it evoked pain as well as "funny feeling," and when the needle finally

penetrated the spinal theca he complained of the "funny feeling" only—due no doubt to mechanical stimulation of the dorsal root fibres.

3. *The Distribution of the 'Archæsthesia.'*—"Funny feeling" was evoked by stimuli applied to any part of the affected side of the body below the level of the second rib. Its upper limit varied with the type of stimulus employed, and for a short distance below there was a belt of skin on which stimuli evoked both ordinary feeling (such as touch, pain and heat), and "funny feeling" (*Figs. 6 and 7*). A stimulus applied to this area was said by the patient to be "between the good and the bad."

The mesial limit of the area on which archæsthesia could be demonstrated encroached on the right half of the body, and there was also a dorsal and ventral longitudinal belt in which ordinary feeling was mixed with "funny feeling"; the left lateral margin of this lay a little distance from the midline of the body. On the dorsum penis the area of "mixed" feeling was narrow, but it included the whole of the left half of the glans as well as the scrotum—save for cold stimuli, when there seemed to be no "mixed" feeling (*Fig. 8*). Pressure on the left testicle gave "funny feeling" only, and on the right the normal sensation.

FIG. 8. — Diagram showing sensory disturbances on the left halves of the penis and scrotum. Dotted area = "funny feeling" only. Shaded area = "mixed" feeling. On this area tactile, pain and heat stimuli were appreciated as such, but accompanied by "funny feeling." Cold stimuli on the same area gave "funny feeling" only.

the trunk and the ordinary radicular anæsthesia on the upper limb, within which both hypæsthesia to light touch and "funny feeling" could be demonstrated.

4. *Absence of Appreciation of Difference in Quality.*—Although in this subject every type of stimulus gave sensations which were indistinguishable in quality, it was still possible that he might in some way detect a difference between them if they were suitably presented. To test this two different types of stimulus were applied one after the other, or either of them was employed twice in succession. The subject was instructed to limit his response to a statement of whether successive stimuli appeared to him similar ("the same") or dissimilar ("different"). It was then found that tactile, pressure, pain and thermal stimuli taken in pairs in various combinations gave no indication of the appreciation

of difference. At one time, however, a slight difference was detected; the sensation given by a pinprick "ran more through him" than that given by firm pressure with a leather disc.

5. *Absence of Appreciation of Difference in Intensity.*—A similar method of test ("same-different" test) was employed for investigating the appreciation of difference in the intensities of sensation. The method showed that stimuli given by cotton wool contact and by strong pressure with the end of a pencil all evoked sensations which appeared indistinguishable as regards intensity.

6. *Absence of Appreciation of Difference in Extensity.*—The sensations produced by the contact of bodies of different sizes were apparently identical. Thus, pressure with a round leather shape 2.5 cm. in diameter was indistinguishable from pressure with the head or point of a pin.

7. *Absence of Appreciation of Difference in Local Signature.*—A stimulus applied to the affected area was described as "all over" or "running all through" him, and if care was taken to exclude the possibility of the patient's localizing stimuli by inference from the position or direction of the voice of the observer, it was found that localization was not correct, even to the gross anatomical regions of the body. When a stimulus was drawn over the skin of the affected area the patient stated that he had no feeling of its movement.

8. *Absence of Appreciation of the Number of Stimuli given synchronously or successively.*—Provided the phenomenon of 'alloæsthesia' did not occur, the subject was completely unable to distinguish two synchronous stimuli from a single one, no matter how far apart they were applied. He was also unable to distinguish two successive stimuli from a single stimulus if the interval of time which elapsed between them did not exceed four or five seconds. Thus, two successive scratches with a pin evoked two distinct "funny feelings" if the interval of time between them was of six seconds' duration. When the interval was four seconds he usually replied that there was only one "funny feeling," and if only four seconds intervened he invariably said that only one stimulus had been given.

When the stimuli were sufficiently wide apart to evoke two separate "funny feelings" he had no idea whether they were similar or dissimilar in locus—even when one was applied near the inferior angle of the scapula and the other on the ventral surface of the lower half of the abdomen. It was also found that, if two pinpricks were given at the same level in such a way that the second stimulus followed before the withdrawal of the first, there might then be an apparent increase in the intensity of the resulting sensation, provided the distance between the two points of application was not less than 24 cm. But this increase in intensity was never observed when the two stimuli were applied in the

same vertical line, even when the first was given on the scapular region and the other on the back of the left thigh. Further examination of this apparent increase in intensity on application of the second stimulus showed that it only occurred at horizontal levels above the left nipple. In other words, it occurred only in that part of the affected area where there was a mixture of "funny feeling" and ordinary feeling.

TEMPORAL RELATIONS.

1. *Latency*.—The reaction time (the latency of the response) was found to vary with the intensity of the stimulus, being longer for light touch and shorter for pain or faradism. It was always long and, provided 'alloæsthesia' did not occur, was on an average about three or four seconds of time for tactile, pressure, pain, faradic and thermal stimuli. This latency applied to the termination of stimulation as well as to its commencement.

2. *Summation*.—If light touch or pain stimuli were rhythmically repeated he reacted with a shorter reaction time than when a single stimulus was given. When, for example, pinpricks were applied at a rate of about two or three a second, his reaction time coincided with the third or fourth stimulus, but if a single prick was given his reply occurred at the point where otherwise a sixth or seventh stimulus would have been reached.

3. *Duration*.—He was unable to distinguish stimuli of different durations one from another.

PHENOMENA OBSERVED ON STIMULATION OF THE SOLE OF THE LEFT FOOT.

At a comparatively early stage it was discovered that on the sole of the left foot there was less disturbance of sensation than on other parts of the affected area. The subject stated that when walking or standing he had a strong "funny feeling" in the left foot, and an investigation of this area yielded the following facts :—

1. *Distribution*.—The area corresponded with the cutaneous distribution of the fifth lumbar and first sacral afferent root fibres on the sole of the foot (*Fig. 3*).

2. *Quality*.—All stimuli applied to this area gave sensations described as similar to the "funny feeling" evoked elsewhere, but in a stronger degree. The sensation was not at all like the "mixed" feeling obtained on stimulation near the boundary demarcating the cephalic and mesial borders of the affected part of the body. It was described as disagreeable, but not painful, and the sensation evoked by pinprick was stated to be more disagreeable than that given by light touch.

3. *Intensity*.—The subject was able to distinguish between stimuli,

which differed only in intensity, provided that difference was great. Stimuli of equal intensities, applied one to the sole and one to the dorsum of the left foot, seemed to differ in intensity, the former being described as more disagreeable.

4. *Local Signature*.—The subject referred all stimuli applied to the sole of the left foot correctly to that area, but within it localization was quite impossible. It is probable that there was no element of local signature, but that the patient inferred from previous experience that the sole of the foot had been stimulated.

5. *Number*.—The duality of two successive stimuli applied 8 cm. apart was recognized if the interval of time between them was about one and a half seconds, and when two similar stimuli were given synchronously at a distance apart of 10 cm. or more he could distinguish them from a single stimulus.

6. *Extensivity*.—Objects of different sizes could not be differentiated when they were pressed upon the sole of the foot.

7. *Weight*.—Provided the difference was great, the patient could state which of two weights was the heavier or lighter when they were applied to the left sole, but he arrived at a decision merely by calculating from the apparent intensity of the sensation, and would say “that’s heavier” (or lighter), “judging from the funny feeling.” There was therefore no true feeling of difference in weight or pressure.

8. ‘*Hardness*’ and ‘*Softness*.’—The subject appeared able to say whether his left foot was upon hard or soft ground, and when questioned about this he stated that he had no actual feeling of hardness or softness, but that if he stepped on to hard ground from soft (or *vice versa*) there was a change in the “funny feeling.”

9. *Kinæsthetic*.—Passive movement of the left hallux elicited “funny feeling” only, but there seemed to be a vague reference of this to the left foot.

PHENOMENA OBSERVED IN THE ‘NEUTRAL’ AREA BETWEEN THE AFFECTED AND NORMAL PARTS OF THE BODY SURFACE.

The normal overlapping in the cutaneous distribution of the dorsal spinal roots gave a sort of ‘neutral’ area, in which stimuli evoked “ordinary” feeling and “funny feeling” at one and the same time. The “ordinary” feeling in this territory varied in intensity with the strength of the stimulus employed, and also with the distance of the point of stimulation from the completely normal cutaneous surface on the right side. The ordinary component in the “mixed” sensation became progressively weaker as the stimulus was applied more and more towards the ‘archæsthetic’ area, and at the same time the “funny feeling” component became progressively stronger.

In the neutral area the “funny feeling” obtained local sign, but the phenomenon was not quite the same in the two main divisions of

this belt. In the vertical area near the middle line of the body the "mixed" feelings were felt on both sides at once, but in that part of the "mixed" belt which ran more or less transversely across the upper aspect of the thorax, the "funny feeling" was said to be "alongside the ordinary feeling." The subject was quite clear that the two feelings ("ordinary" and "funny") were present together at the same time, and he was equally certain that the "funny feeling" seemed to lie alongside the ordinary feeling, and was not "all through him."

THE BOUNDARIES OF THE DISTURBED AREA.

It is known that the fibres of any one dorsal nerve root cross over to the opposite side of the spinal cord in groups which have different degrees of obliquity. In the cervical region, where this obliquity is marked, fibres subserving the passage of thermal impulses seem to cross within about three segments, pain fibres in about four segments, and tactile fibres still more obliquely. Consequently, if a lesion falls on one half of the spinal cord there will be a divergence between the upper limits of the various types of sensory loss—the upper margin of therm-anæsthesia will be higher in segmental order than the upper border of pain or tactile loss. Physiology has also established that the edges of adjacent segmental areas overlap in such a way that the lower edge of one segmental area touches (or even overlaps) the upper edge of the area next but one below it. As, therefore, in the case under discussion "ordinary" feeling was found along with "funny feeling" near the upper limit of the remote sensory effects, it was possible to map out not only the upper boundary of the area of disturbance for each form of stimulus, but also the lower boundary of the overlap of unaffected fibres (*Figs. 9 and 10*). In practice, however, this was not altogether easy to do, as the gradual diminution in strength of the ordinary feeling as the stimulus was applied in a caudal direction, and the gradual diminution in intensity of the "funny feeling" as the stimulus travelled in a cephalic direction made the exact mapping of the upper and lower boundaries a matter of some difficulty.

From above, downwards, the various horizontal boundaries were as follows:—

(A) Upper limit of 'archæsthesia' evoked by cold stimuli. This level lay in the interspace between the first and second ribs in front.

(B) Upper limit of 'archæsthesia' evoked by pinprick. This line lay about 1 cm. below A. Localization was perhaps impaired from this line downwards.

(C) Upper limit of 'archæsthesia' evoked by deep pressure. This line lay very slightly below B, and either this boundary or the one immediately above it was the upper level of 'archæsthesia' evoked by traction on the skin.

(D) Upper limit of failure of discrimination of two simultaneous pressure contacts applied 6 cm. apart. This line was probably slightly below C and about 1 cm. below D.

(E) Upper limit of 'archæsthesia' to light touch stimuli. Also

FIG. 9.—Diagram illustrating the upper boundary of the area of sensory disturbance for each form of stimulus, together with the overlap of "ordinary" sensation from the unaffected segments above the level of the lesion. *u* = upper; *l* = lower.

upper limit of definite impairment of localization. This line lay 2 cm. below D and 3 cm. below B.

(F) Upper limit of 'archæsthesia' evoked by heat, and lower limit of ordinary sensation evoked by cold. Line F lay about the level of the lower border of the third rib.

(G) Lower limit of ordinary sensation evoked by pinprick and by

traction on the skin. Its level corresponded to about the upper border of the fourth rib.

(H) Lower limit of ordinary sensation evoked by deep pressure stimuli. Towards the ventral midline it corresponded with G, but laterally it ran below it.

(I) Lower limit at which a moving pressure stimulus appeared to the subject to be moving. Mesially this line corresponded with H, but laterally it lay rather lower.

(K) Lower limit of ordinary sensation to touch stimuli and lower limit of definite impairment of localization. Below K localization was impossible. A little internal to the nipple this line lay at the lower border of the fourth rib.

The relation of these lines to the boundaries of the cutaneous segmental distribution of the afferent nerves is a matter of some interest. If we accept Dejerine's diagrams as a standard, the following results are obtained. Line A (upper cold limit) corresponds exactly to the upper boundary of the second thoracic segmental area, while line E corresponds to the boundary between the segmental distributions of the second and third thoracic root areas. In a similar manner, lines E and I correspond to the boundaries between the segmental distributions of the third and fourth, and fourth and fifth dorsal roots respectively. The remaining lines showed no definite relationship to segmental boundaries.

OBSERVATIONS ON THE COORDINATION AND MOVEMENTS OF THE LOWER LIMBS.

The phenomena observed in connection with the movements of the left lower limb were of unusual interest. Posture was maintained normally, and little disturbance of common, more or less automatic, movements could be noted, even when the subject's eyes were covered. He walked almost normally and could perform the movements of "quick-mark time" with fair accuracy. In the recumbent posture he flexed and extended the left limb to command without noticeable defect. There seemed, however, to be a greater latency in the performance of movements on the left side, for if he was told to bring both heels up to his buttocks simultaneously, there was an unmistakable lag on the part of the left leg.

If the patient's eyes were covered the results were very different, and at first it was only with the greatest difficulty that he managed to move the left limb at all. Thus, if he was instructed to bring his left heel up to his buttock, he made a preliminary movement with the right leg, groping about as if in search of its fellow, and, strangely enough, this was often succeeded by a second movement of the right limb alone, the left remaining absolutely passive on the bed. In tests where one of

two opposite movements was possible—as when the limb had been first placed in a semi-flexed posture—he moved the limb sometimes in the correct direction and sometimes in the wrong, and occasionally made no movement at all.

Although the movements of “quick-mark time” were fairly well executed in the standing posture, even when the subject’s eyes were covered, they became extremely incoordinate as soon as he was asked to perform them lying down. It was then observed that at first the right limb moved rhythmically by itself; a little later the left commenced to move incoordinate—sometimes synchronously and sometimes alternately with the right limb; and, finally, the left limb settled

FIG. 10.—Posterior aspect of chest wall. Certain of the lines seen in *Fig. 9* are depicted. They are, from above downwards—upper limit cold, upper limit pain, upper limit touch, lower limit cold and upper limit heat, lower limit pain, lower limit movement, lower limit touch, lower limit heat.

FIG. 11.—Illustrates the patient's error in the performance of measured movements with the left lower limb. The subject was first allowed to see the ruler held a few inches off the bed; his face was then covered, and he was instructed to raise the left heel to a similar height.

down into accurate alternation, although the movements remained shallow in amplitude. If at this stage the cover was removed from his eyes the normal rhythm was at once established. The difference between these results in the upright and supine positions seems remarkable, but it must be remembered that there is a distinct physiological difference between the two, for, in the former, extension is, or may be, a passive movement conditioned by gravity, while in the latter it must be an active movement. It is also possible that the patient derived some assistance when standing from the contact of his left sole with the ground, for under such conditions he experienced a “funny feeling,” which had in it a coarse element of local signature. The effects of practice must also be taken into account, since he had trained himself to perform these movements in the upright posture. As time went on a

similar training exerted a favourable influence on the movements performed in the recumbent posture; they became more regular, and he now only rarely failed to move the left limb when told to do so, although the movements were still of a maximal extent (*Fig. 11*). But even when he had learnt by practice to flex and extend correctly at the various joints of the left limb, he was still unable to make a movement of an unusual character. For example, when told to perform "left turn" (i.e., outward rotation at the hip) he gave a maximal movement of abduction. It was also instructive to note that with the appearance of this comparative regularity the curious movements on the right side in the period of latency diminished, to the extent that they were now replaced by a contraction of muscles which corresponded with those which were brought into operation in the left limb. Thus, when the left heel was raised from the bed, the right rectus femoris was felt to contract before and during flexion of the left hip, and to relax again just before the left limb was allowed to fall.

Lastly, it may be mentioned that although the patient was hopeless in his attempts to touch his right knee with his left heel, he was yet able to do so under the guidance of tactile stimuli, for if the left heel was placed in contact with the lower part of the right leg he found the right knee with comparative ease by sliding the heel up the limb.

ALLOÆSTHESIA.

The term 'allocheiria' was originally given by Obersteiner to a condition in which "though the sensibility is retained more or less completely, the patient is not clear, or is frequently, if not constantly, in error as to which side of the body has been touched." The cardinal features of the condition so defined are, first, that there is in the patient's mind doubt or error as to the side touched, and secondly, that sensibility, including the power of localization, is otherwise retained. For those cases in which the second feature is not present, it is better, as Ernest Jones² has emphasized, to employ the term 'false allocheiria' or 'alloæsthesia.'

When we came to examine our patient's power of localizing stimuli on the affected side he volunteered the information that the "funny feeling" evoked by a stimulus sometimes shot over to the opposite side. He had no doubt or error as to which side of the body had been touched, as he had already observed that the "funny feeling" was only associated with stimuli applied within its boundaries. The condition was, therefore, one of 'alloæsthesia.'

When the patient came under observation his localization of touch and pressure touch was found to be defective on the left side of the trunk and on the left lower limb; touch stimuli were at first placed correctly on the left side of the body. They were very seldom referred to

the actual spots touched, and after the lapse of a few days showed an increasing tendency to be referred to the opposite side (*Fig. 12*). To pain and thermal stimuli his reactions varied. Above the upper limit of the 'archæsthetic' area there was accurate localization, but below

FIG. 12.—Illustrates the patient's early defect in the localization of touch stimuli.

this level stimuli were not always capable of localization, as the feeling "ran all through him" (*Figs. 13 and 14*). Proceeding further in a caudal direction it was found that on an area slightly below the left nipple many stimuli were referred to the other side of the body, and a few either correctly localized or described as "running all through him."

At a still lower level, which appeared to correspond to the eighth,

ninth, tenth, and eleventh thoracic segmental areas, mirror localization occurred most markedly (*Fig. 14*), but in the immediately subjacent

FIG. 13.—Illustrates the gradual development of 'alloesthesia' to *pain* stimuli. Tactile stimuli localized correctly.

FIG. 14.—Illustrates the localization of *cold* stimuli at an early stage before the power of localization was completely lost on the left side. Tactile stimuli localized accurately. Pain stimuli in the shaded area gave the phenomenon of 'alloesthesia.'

twelfth thoracic and first lumbar areas pain and cold stimuli either failed to evoke any reaction at all or gave rise to the feeling which was not capable of localization. Similar stimuli applied to the left lower limb

were sometimes localized with no error, sometimes with marked error, and occasionally they were referred to the opposite limb.

At this time heat stimuli gave 'alloæsthesia' with great constancy on the left side of the thorax, and especially the abdomen (*Figs. 15 and 16*), and it was noticed that the spots which gave the reaction were constant in position—the stimulation of neighbouring points nearly always failing to evoke the phenomenon.

As time went on the boundaries of the area within which stimuli were adequate gradually extended, until the reaction could be demonstrated on the whole of the left side of the body from the second rib downwards, and with practically any form of stimulus.

DESCRIPTION OF THE PHENOMENON IN ITS FINAL STATE.

A weak stimulus evoked the "funny feeling" which had no definite locus, but if its strength was gradually increased, at a certain point the

FIGS. 15 AND 16.—Show the gradual development of 'alloæsthesia' to heat stimuli on the left side of the abdomen.

"funny feeling" appeared to jump over to the opposite side of the body, and was referred to a situation which was found to be the accurate mirror localization of the site of the stimulus. The patient stated that when the phenomenon occurred two feelings seemed to co-exist—the original "funny feeling," and its counterpart, which appeared to be on the right side. The latter possessed a vague quality "like a tickliness with a little pain in it," and never varied when different kinds or strengths of stimuli were employed. On withdrawal of the stimulus the crossed feeling was stated to "jump back" at the same instant that he lost the "funny feeling" on the left side of the body.

The reaction to the apparent crossing was of two kinds. In the first place, there was invariably a well-marked motor response, which

took the form of a sharp bump with the knuckle of the right thumb on the site of mirror localization (*Fig. 17*), and if the latter was situated on the abdomen, a brisk contraction of the right abdominal muscles accompanied this reaction. It is interesting to note that the movement of the patient's hand was a very rapid one and apparently beyond his voluntary control, for he was never able to inhibit it. In the second place, there followed the speech reaction, the patient usually remarking "It's jumped," or "It's over."

FIG. 17.—Shows the patient's motor response to the phenomenon of 'alloæsthesia.'

The Mirror Localization.—In making a mirror localization the subject almost never varied from the exact horizontal level, his error being confined to slight variations in its distance from the midline. The following table illustrates the comparative accuracy of mirror localization in the transverse direction. The figures in column A represent the distance of the stimulated spots from the midline of the body; those in column B the distance of the mirror localizations from the midline, and those in column C the

order in which the observations were made. A thermal stimulus was employed throughout the experiment.

A.		B.	C.
3.5 cm.	.	3 cm.	12
4 "	.	4 "	7
6.5 "	.	5 "	2
7 "	.	5 "	5
7.5 "	.	5 "	1
10 "	.	10 "	11
11 "	.	9 "	8
13 "	.	12 "	13
13.5 "	.	11 "	6
15 "	.	14 "	10
15 "	.	12 "	9
16 "	.	15 "	4
20 "	.	18.5 "	3

Average error : 1.4 cm.

THE DISCRIMINATION OF TWO SYNCHRONOUS CONTACTS.

Although apparently quite unable to recognize the duality of two synchronous stimuli, even when the points of the compass were separated by a distance of 100 cm., the patient at once recognized the doubleness of contact if the two stimuli were so placed as to condition 'alloæsthesia.'

The following table gives the result of the compass test for pain stimuli applied at the umbilical level :—

Synchronous Two-point Threshold.

Right Side.			Left Side.		
	single	error		single	error
2 cm.	/ x x / / / x /	=3	2 cm.	/ / / / / / /	=0
	double			double	
	/ x x / / x x x / x	=7		x x x x x x x x	=10
3 cm.	/ / / x / / x /	=2	3 cm.	/ / / / / / /	=0
	/ x x x / / / / /	=3		x x x x x x x x	=10
4 cm.	/ / / / / / /	=0	4 cm.	/ / / / / / /	=0
	/ / / / / / /	=0		x x x x x x x x	=10
2 cm.	/ / / / / / /	=0	5 cm.	/ / / / / / /	=0
	/ / / x x x x x / x	=5		/ / / / / / /	=0
Threshold = 4 cm.			4.5 cm.	/ / / / / / /	=0
				x x x x x x x x	=10
			Threshold = 5 cm.		

HETERÆSTHESIA.

While investigating the phenomenon of 'alloæsthesia' it occurred to us that it might be possible to map out the boundaries of the area within which it was obtained by drawing an electrode over the skin and asking the subject to indicate when the sensation "jumped over." If the faradic stimulus used was a strong one the phenomenon was obtained without interruption, and the apparent site of the stimulus on the right side of the body appeared to travel in the mirror direction to the true one. When, however, a comparatively weak stimulus was employed some curious and unexpected results were obtained, for if the electrode was drawn down the left side of the thorax 'alloæsthesia' did not occur until a certain level a little below the nipple had been reached; and when the progress of the electrode was continued in a caudal direction the phenomenon was often found to cease, and again to reappear and disappear alternately as different levels were crossed. In this manner, by repeatedly drawing a weak faradic stimulus down imaginary parallel lines a large number of "points of change" (where 'alloæsthesia' occurred or disappeared as the stimulus passed over them) were located and permanently marked. It was then found that the points had a certain constancy, and when joined together formed lines which corresponded very exactly with the boundaries of the radicular or segmental areas (*Figs. 18—21*). For this peculiar state, whereby difference in the degree of sensation is experienced when stimuli of equal value are applied to different parts of the skin or other sensory receptive field, we proposed the term 'heteræsthesia.'

The results described above were obtained most easily with a weak faradic stimulus, but any form of stimulus which gave 'alloæsthesia' was found to be effective, and when a 'heteræsthetic' change was experienced by the subject it always occurred at a line and never in the space between two lines. In other words, if the stimulus was confined within the boundaries of a single segmental area the phenomenon of 'alloæsthesia' showed no tendency to appear, even when the distance traversed was great.

Lastly, it may be remarked that 'heteræsthesia' was not obtained with equal facility on all parts of the affected side. The lines on the

FIGS. 18-21.—Show the lines of 'heteræsthesia.'

abdomen and lower limb were readily obtained, while those on the buttock and between the iliac crest and great trochanter were only found by repeated examination.

CONCLUSIONS.

Although a full discussion of the peculiar phenomena observed in this case would lead too far from the clinical purpose of this paper, it is perhaps permissible to offer some remarks on certain aspects of the sensory disturbances which claimed our attention.

The phenomena which this patient presented were so unusual that the question of a 'functional' element in the case at once arose. We knew that hemianæsthesia is a common hysterical manifestation, and that suggestion may easily play a part in the development of sensory disturbance, especially when the subject is examined daily over a long period of time. In conducting our examination we were, therefore, careful to avoid leading questions and suggestions, and to make full use of those tests by which hysterical sensory phenomena can usually

be demonstrated. Our conviction of the organic nature of the sensory phenomena is, we think, to a great extent supported by a consideration of their distribution on the left side of the body. When anæsthesia is hysterical its distribution usually bears no characteristic relation to that of the spinal segments, and its upper limit often varies widely, depending on suggestions given during examination. In our patient the distribution of the alterations in sensibility was not like those encountered in hysteria. The affected area encroached slightly on the right half of the body, and, more important, its upper limit varied with the type of stimulus employed and was blended with a belt of ordinary feeling; moreover, within a limited area on the sole of the foot certain attributes of ordinary sensation were retained. Finally, when stability had been attained the various boundaries which we had marked permanently with silver nitrate remained constant and could not be altered by suggestion.

From a study of the various motor and sensory phenomena in the upper limbs it seemed probable that the lesion extended in a vertical direction from the fifth cervical to the first thoracic segments, and had finally completely interrupted conduction in the right spinothalamic tract and in all the fibres of the left dorsal columns. It may also be inferred, from the fact that there was no evidence of disturbance of function in the descending and ascending tracts of the left antero-lateral columns (pyramidal tracts, crossed tracts for pain, heat and cold), that the afferent cerebellar fibres had escaped destruction. The condition, therefore, seems to have destroyed all afferent paths between the left side of the body and the cerebral mechanism without injuring those between the left side and the cerebellar-red nucleus apparatus. It is therefore feasible to suppose that the phenomenon of 'archæsthesia' depended on the interruption of all afferent tracts which normally convey impulses subserving the different attributes of sensation, and upon the retention of a tract which can convey centripetal impulses to the cerebral apparatus, either directly or indirectly. As already mentioned, the left anterolateral tracts had apparently escaped injury, and it is conceivable that the impulses conveying the "funny feeling" ascended in the spinocerebellar tracts, eventually to reach the cerebrum by cerebello-cortical paths. If this was so, each kind of peripheral afferent nerve fibre must, besides its normal function of transmitting impulses to specific afferent tracts in the cord, send impulses into this common tract, which may, as it were, serve as a common denominator for all peripheral afferent impulses. To explain satisfactorily how 'archæsthesia' is not a recognizable sensation in the normal subject, it would then be necessary to fall back on the assumption that normally the innumerable impulses reaching the cerebral cortex directly from the spinal cord swamp out of consciousness those impulses which come by a

circuitous and, perhaps older path, and that 'archæsthesia' can only occur when the cortical background is wiped clean by the cutting out of all direct paths.

The assumption that the spinocerebellar tracts on the left side of the cord were uninjured may also be made use of to explain the remarkable disorder of coordination and movement observed in the left lower limb. It will be recalled that posture was accurately maintained. When the subject's eyes were covered, common movements, such as those of progression and "quick-mark time," were performed easily and with fair accuracy, provided he was standing upright. But measured movements—such as placing the left foot in a given position—were at first almost impossible and markedly incoordinate. When, however, guidance was permitted from normal sense organs the movements were performed in an almost normal fashion. Now it is probable that the forms of activity concerned with the maintenance of posture and with the execution of more or less automatic movements are conditioned by the cerebellar-red nucleus mechanism, and that those concerned with finer and more exact movements are conditioned very largely by the cerebral apparatus. It is possible that the afferent paths for the former mechanism were intact, while those from the left side of the body for the latter mechanism were interrupted. In its motor phenomena the case, therefore, presented a condition which may be termed the 'syndrome of cerebral apæsthesia,' this syndrome consisting in a disturbance of voluntary movement in the affected limb, whereby at first such movement cannot at all be performed or can only be performed under the vicarious guidance of some such sense-organs as the eyes; and wherein finer measured movements are wholly incoordinate if such vicarious guidance be denied. But at the same time the cerebellar functions are retained intact, so that the subject maintains a posture of the affected limb, can stand upright without swaying, and can perform in a coordinate manner those common activities in which both lower limbs take part.

Before discussing the mechanism of 'heteræsthesia,' one fact should be prominently stated. We were able to demonstrate the phenomenon in one other case of spinal cord injury, and in a number of cases of spinal or cerebral concussion, and were thus able to compare the lines on different subjects. We found that they corresponded very closely. Nevertheless, the condition seems to be very uncommon, and since we first described it in 1918³ only one other example appears to have been recorded. Lhermitte and Cornil⁴ describe the case of a soldier who was rendered paraplegic by a gunshot wound in the neighbourhood of the second dorsal vertebra. When examined more than two years later zones of 'heteræsthesia' were found, corresponding exactly to the distribution of the first, second, and third lumbar, and part of the second sacral sensory nerve roots. In this case it is interesting to note

that attention to the phenomenon was first directed by the patient himself.

It must be admitted, however, that there is a grave danger of the observer suggesting these lines to the subject. He may, for example, draw the stimulus rapidly over an indifferent area, and more slowly on an area where he expects to find a line, or he may press more heavily when he comes to the expected line. With these possibilities in mind we were careful to avoid any form of suggestion and were able to convince others as well as ourselves that the phenomenon was not a hysterical manifestation.

With regard to the topography of the lines, they had, of course, a very vivid resemblance to the boundaries of root areas, and the comparative absence of overlapping was therefore rather puzzling. If the lines of change had been those delimiting root areas we would have expected to find about double the number we actually encountered. We may hazard the suggestion that overlapping may not occur to the same extent in segmental areas, and that the lines of change in this patient were those of segmental, and not root areas.

To explain the mechanism of this phenomenon, two hypotheses may be advanced. It may be supposed that under normal conditions there exists a central mechanism controlling or levelling the states of excitability of adjacent segments of the spinal cord, and that when the coordinating paths are interrupted adjacent segments assume different states of excitability. In these circumstances the values of equal stimuli may be different when the ingoing nerve impulses which they engender impinge upon the various segments of the cord. A second hypothesis, offered by Lhermitte and Cornil, has the merit of simplicity. It postulates that the phenomenon is related to an unequal implication of the intraspinal sensory fibres, which are known to retain their radicular grouping in their passage through the spinal cord.

REFERENCES.

- ¹ BROWN-SÉQUARD, *Thèse pour le doctorat en médecine*, 1846.
- ² JONES, ERNEST, *Brain*, 1907, xxx, 490.
- ³ BROWN, GRAHAM, and STEWART, *Rev. of Neurol. and Psychiat.*, 1918, xvi, 225.
- ⁴ LHERMITTE, J., and CORNIL, L., *L'Encéphale*, 1922, xvii, 201.