Experiments in examination of the peripheral distribution of the fibres of the posterior roots of some spinal nerves / by C. S. Sherrington.

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EXPERIMENTS IN EXAMINATION OF THE PERIPHERAL DISTRIBUTION OF THE FIBRES OF THE POSTERIOR ROOTS OF SOME SPINAL NERVES.

BY

C. S. SHERRINGTON, M.A., M.D.

"Experiments in Examination of the Peripheral Distribution of the Fibres of the Posterior Roots of some Spinal Nerves."

By C. S. SHERRINGTON, M.A., M.D., Lecturer on Physiology at St. Thomas's Hospital, London. Communicated by Professor M. FOSTER, Sec. R.S. Received December 2, 1892.

(From the Physiological Laboratory of St. Thomas's Hospital, London.)

(Abstract.)

After reference to the experimental researches of Eckhard, Peyer, Krause, Koschewnikoff, Meyer, and Türck, and to the anatomical of Herringham and Paterson, mention is made of clinical observations by Thorburn, Starr, Mackenzie, Head, and others. The methods employed by the author in experiments on the Frog, Cat, and Monkey are then detailed. In the two latter animals the effect of consecutive sections in ascending or descending series upon the reflex movement elicitable by electrical excitation of the central end of a peripheral nerve was observed, and followed as a guide to the central connexions of the nerve. In the first- and last-mentioned animals mechanical excitation of the cutaneous surface, after previous section of a number of posterior roots above and below the root to be examined, was employed to detect the peripheral distribution of the nerve-root in the skin. The various experiments performed are individually described, and the results of each series are collated. The cutaneous fields of the thoracic and post-thoracic afferent spinal roots are shown in photographs, and in sketches made at the time in the laboratory. The photographs illustrate also the chief outlines of the segmental skin-fields of the cervical sensory roots; but description and discussion of the roots, above the 1st thoracic, are reserved for a future communication.

The author finally proceeds to draw conclusions of the following nature:—

The field of skin belonging to each sensory spinal root may be called the segmental skin-field. In each segmental field reflex reaction is less easily elicitable near the edge of the field than from the field elsewhere. The segmental fields do not present the same configuration as do the fields of the peripheral nerves.

Although in a plexus each posterior spinal root gives separate contributions to many several nerve-trunks, the cutaneous distribution of the root is composed not of patches which are disjoined, but of patches which are so joined that the distribution of the entire root forms one continuous field. Similarity of the root composition of neigh-

bouring nerve-twigs, that are near their destination, is a necessity of this arrangement. Thus, the dorsal collateral digital nerve, on the tibial side of a digit, will resemble, in composition, the plantar collateral digital on the tibial side of the same digit, although they are derived from separate parent trunks. This is comparable to the similarity of root composition exhibited by the several motor twigs entering one and the same muscle. Thus, the tibialis anticus frequently receives fibres from three motor spinal roots, and receives those fibres by at least three several nerve-branches entering it; the root composition of each of the nerve-branches is approximately the same. The dorsal digital supplying the cleft between the 1st and 2nd digits is interpolated in the series of digitals from the musculocutaneous nerve, although it comes itself from the anterior tibial. Yet it, by its root composition, falls into perfect series with the other digital nerves.

Each segmental skin-field spreads, to a certain extent, across neighbouring segmental skin-fields. It has a *fore-lap* extending into segmental fields immediately anterior to it; and an *after-lap* extending into fields immediately posterior; it has also cross-laps extending into the corresponding fields on the other lateral half of the body, both at the mid-dorsal line (the *dorsal cross-lap*) and the mid-ventral line (the *ventral cross-lap*). The *fore-lap* and the *after-lap* are, throughout the body, very great, and each region of skin appears to be supplied by at least two sensory spinal roots. The over-lap of the skin-fields of the individual filaments of a posterior root is great.

The shape of a segmental skin-field is, where simplest, *e.g.*, in the trunk and neck, band-like, wrapping transversely round one lateral half of the body; it has fairly parallel edges, but is somewhat broader near its ventral than at its dorsal end. In the limb the segmental skin-fields are *distorted* from the simple band-like type. The distortion of each segmental field in the hind-limb, and of some in the fore-limb, is, in the full paper, analysed, and for each the true anterior border, the true posterior border, and the true dorsal and ventra borders are found. This analysis is only possible after it has been recognised that in the limb the cutaneous segments are not only distorted but are seemingly *dislocated* from their attachments to the mid-dorsal and mid-ventral lines of the trunk.

The mid-dorsal line of the body may be said to, in the region of the limb, extend outwards as a side branch, a secondary axis, almost at right angles to itself. The same is done in the same region by the mid-ventral line. Upon these dorsal and ventral side lines as upon secondary dorsal and ventral axes, the cutaneous segments of the limb are ranged, as though upon folded portions of the axial lines of the trunk itself.

The axial lines for the hind-limb slant outward from the trunk

axis in a somewhat backward as well as lateral direction; those for the fore-limb conversely slope somewhat forward as well as outward. The *dorsal axial line* in the hind-limb runs from the mid-dorsum over the sacrum, past the back of the hip-joint, and along the outer face of the thigh nearly to the knee. Of the dorsal axial line of the fore limb only the most proximal part is described by the present experiments; that part runs from the mid-dorsum outwards and forwards over the infra-spinous fossa of the scapula. The *ventral axial line* of the hind-limb runs from the front of the body of the pubes to the inner border of the thigh, and descends along the junction of the extensor and adductor groups of muscles nearly to the knee. The *ventral axial line* of the fore-limb is in the present experiments only followed for its proximal part; that part lies on the chest close below the clavicle.

The position of these secondary axes having once been found (by methods described in the paper) in the limb, it is not difficult to examine the degree of apparent dislocation of each segmental field and the nature of its distortion. In the segmentally anterior aspect of the limb each segmental field has been curved so as to present a very convex posterior edge, and the after-lap of the field is very large. In the segmentally posterior aspect of the limb each segmental field has been curved so as to present a very convex anterior edge, and the fore-lap of the field is very large. The dorsal and ventral borders of the fields are, in the limb, not much increased in length. Owing to their serial arrangement along the secondary *mid-dorsum* and *mid-venter* of the limb there is a secondary cross-lap of the fields there of such a kind that a segmental field may there cross-lap with a segmental field far distant from it in the segmental series; thus the 9th post-thoracic field may cross-lap with the 4th post-thoracic field.

This dislocation of some of the segmental fields in the limb from the *mid-dorsum* and *mid-venter* is apparent rather than real, and is not a fundamental character of the limb segmentation, for it does not occur in primitive types, *e.g.*, is absent from the pelvic limb of the Frog.

Using the cutaneous field as a guide to the morphological position of various points in the body, it is seen that the edges of the foot and hand are, in the segmental fields of the limb, about midway between the mid-dorsal and mid-ventral lines, and therefore must correspond about with the lateral line of the trunk. The digits are therefore buds from the region of the lateral line.

The vulva and the anus are not at the posterior pole of the body but, like the umbilicus, are placed in the mid-ventral line.

From the motor roots it is not easy to get evidence that the 1st digit of the foot or hand is segmentally anterior to the 5th digit; the root supply of the intrinsic musculature of each is so similar. But

from the sensory roots it is easy to show that the skin of the 1st digit is segmentally anterior to that of the 2nd digit, that of 2nd to that of 3rd, and so on. The skin of the dorsum of the foot is shown to be segmentally anterior to the sole.

The nipple lies in the middle of the 4th thoracic field, but is also included in the fields of the 3rd and 5th thoracic. The umbilicus is in the 11th thoracic root field.

The number of segments entering into the composition of the skin of the limb is seen to be greater than the number of segments contributing to its musculature. To the skin of the anterior aspect of the fore-limb, six segments contribute (3rd, 4th, 5th, 6th, 7th, 8th cervical); to that of the hind-limb six segments also (1st, 2nd, 3rd, 4th, 5th, 6th post-thoracic). To the posterior part of the fore-limb four segments contribute (1st, 2nd, 3rd, 4th thoracic); to that of the hind-limb four segments also (6th, 7th, 8th, 9th post-thoracic).

In each limb the anterior aspect is segmentally more extensive than the posterior. I have shown that this last fact is exemplified even more strikingly in the musculature of each limb.

The quadrifid or quinquifid digital partition at the free end of the limb gives no indication of the number of segmental skin fields in it.

Joints such as knee and ankle, which might perhaps seem natural boundaries marking fundamentally distinct portions of the limb, are not regarded as such in the segmentation of the cord, as evidenced by posterior roots.

The absolute segmental level of a point of surface is subject to individual variation, as was shown to be the case with muscular points in the substance of the body wall and viscera. This individual variation affecting the skin corresponds with variation in the constitution of the efferent roots; the limb plexus may be *postfixed* or *prefixed* by its sensory spinal roots, just as it may be by its motor spinal roots. A mixed nerve may be postfixed by its motor roots and by its sensory in the same individual, or may be prefixed by both. But there is some evidence (Frog) that a plexus may be prefixed by its motor roots when it is not so by its sensory roots, and *vice versâ*.

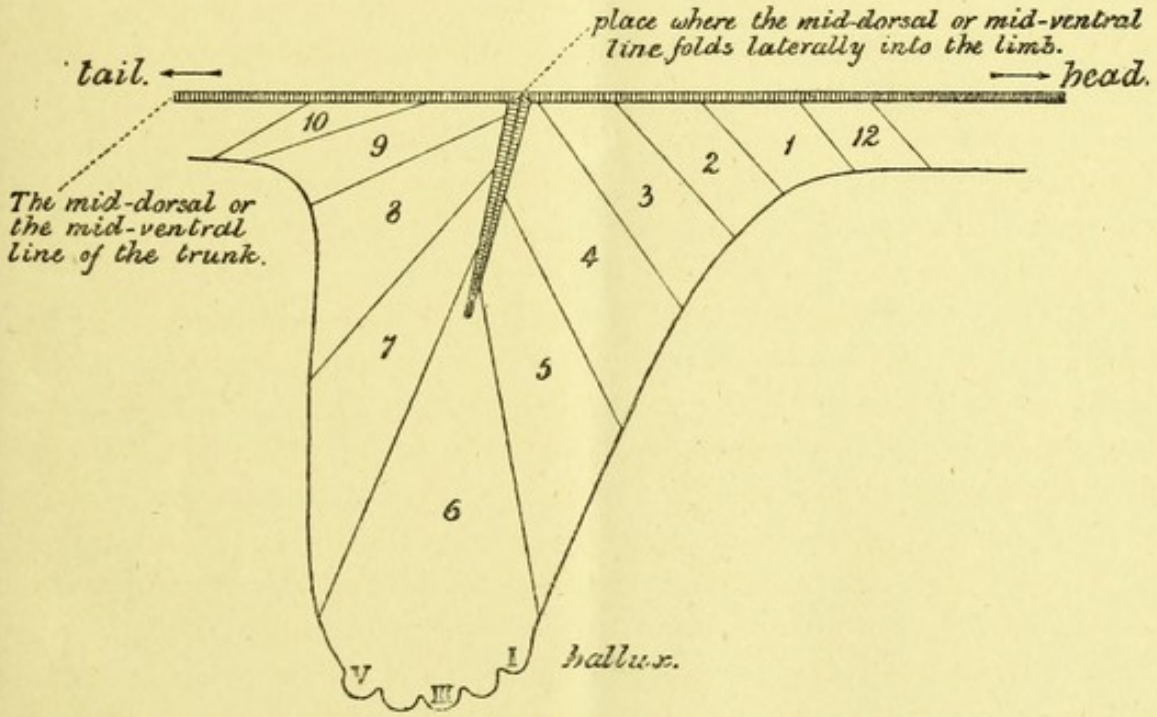
The distribution of the fibres of the sensory spinal root in the limb, as elsewhere, indicates a segmental significance in their constitution rather than a functional based upon coordination. Without denying the existence of functional factors in the progressive development of the limb, it must be admitted that there is little evidence that the collection of fibres in each sensory root has resulted from an assortment of the fibres with a view towards assisting in functional coordination.

Peyer's statement of the correspondence of locality of the muscular and cutaneous distributions of a spinal nerve does not apply in the Monkey. The 9th post-thoracic nerve innervates the intrinsic

muscles of the foot, but its skin-field is on the buttock. In the lower half of the trunk and in the pelvic limb the skin at any point will be supplied by sensory spinal roots segmentally anterior to (higher than) the spinal motor root supplying the subjacent muscle. A partial exception to this will be in the skin of the back of the thigh, where, for reasons explained, the supply of both may be from the same segmental level.

The cutaneous fields of the posterior spinal roots do not correspond with the fields of cutaneous distribution of the motor roots, as judged by the pilomotor fibres of those roots. The pilomotor fields and the cutaneous sensory fields do not correspond.

As to cutaneous vasomotor fields and the cutaneous sensory fields, there does in *Macacus rhesus* seem to be a curious correspondence of the area of "sexual" skin at the root of the tail, on the buttock, and along the back of the thigh with the combined sensory skin field of 10th, 9th, and 8th post-thoracic roots.



Cutaneous Segments of the Pelvic Limb of Monkey, dorsal or ventral aspect.
(The overlapping of the segments is not shown.)

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