THE NEURAL BASIS OF CUTANEOUS SENSATION[1]

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Certain results of a study of the sensory consequences of cutaneous denervation are reported. The experiment was a repetition of the classic experiment of Henry Head, with more subjects and better controlled conditions. Five anaesthetic areas were produced in the left fore-arms of three subjects. Injection of 95 per cent alcohol into the nerve trunk was the method of denervation employed.

The results of the study do not substantiate Head's hypothesis of "protopathic" and "epicritic" systems of fibers in cutaneous nerves. Neither the phenomena of sensory dissociation nor the patterns of sensitivity changes in "intermediate" and in "recovering" areas can be explained by this theory.

The sensory dissociations observed point conclusively to the existence of four types of anatomical mechanisms underlying cutaneous sensibility. The most plausible theory would seem to be that these mechanisms consist of four nerve fiber groups, each of which produces a distinct pattern of nervous excitation or action potential wave. Fiber diameter is probably the most important basis of differentiation of the several groups. This theory receives strong support from recent studies of electrical changes in nerves and from studies of the effects of skin anaesthetics showing selective abolition of sensations, apparently in relation to characteristic fiber groups.

The threshold measurements indicate that "sensation" threshold, in contrast to "threshold" of peripheral nerve fibers, varies somewhat directly with the mass of nerve fibers present in a given skin area. Towards the margin of the receptive field of a nerve (the "intermediate" zone) and in "recovering" areas in the early stages of regeneration, innervation is no doubt relatively sparse, and our results showed that thresholds under such conditions were high. The more intense stimulation necessary is assumed to have evoked a higher frequency of discharge in such fibers as were affected, and perhaps also to have affected fibers relatively remote from the point stimulated.

The larger thermal than touch or pain anaesthesia is explained in terms of the same principle of "mass innervation." Partial denerva-

[1]A complete report of this study will appear in a future issue of the *Archives of Neurology and Psychiatry*, in an article by the writer and his two collaborators, H. M. Carney, M.D., and W. D. Wilson, M.D. Acknowledgments are gratefully made to Dr. R. S. Cunningham, Professor of Anatomy, who sponsored the work, and to Dr. Barney Brooks, Professor of Surgery, who performed the denervation operations. Read before the Tennessee Academy of Science at the Nashville meeting.

tion such as occurs in the intermediate zone would result in relatively greater thinning out of cold and warmth fibers, since their numbers are presumably much less, with the result that the excitation of residual thermal fibers at the outer margin of the receptive field would be inadequate to the arousal of the sensorium. The slightly less extensive loss of cold than of warmth sensitivity is correlated with the greater surface area responsive to cold stimuli and an assumed greater mass of "cold" fibers. The delay in return of warmth could be explained on the same principle; longer time would be necessary for the fewer warmth fibers to return in sufficient number to yield a nervous discharge adequate to activate the sensorium. The fact that cold sensitivity returns as fast as that for touch or pain does not, however, conform to expectations based upon this theory.

The peculiar "protopathic" over-reaction observed in the intermediate zone and in affected areas during regeneration is held to be differently conditioned in the two cases. Studies of action potential waves indicate that intensity of sensation is correlated with frequency of nerve impulses, other things being equal. The temporary hyperaesthesia of the intermediate zone can be explained in terms of an increased excitability of the residual fibers, caused either by local effects (chemical or physical) of degeneration, or by changes in the spinal ganglion, accompanying the axon reaction in affected cell bodies. The hyperaesthesia occurring during regeneration could be due to an increased frequency of discharge in regenerating fibers, analogous to the "injury" discharge described by Adrian. The excessively unpleasant character of the pain thus induced is held to be an instance of thalamic "over-reaction" caused by the abnormal pattern of excitation occurring in the relatively few fibers discharging at high frequencies.

Abnormal localization (peripheral reference) would seem to be due to abnormal fiber terminations; fibers originally ending at more distal points find their way to the skin before reaching these points. Localization is held to be an acquired function and is not believed to depend upon special "localization" fibers.

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THE TENNESSEE ACADEMY LIBRARIAN

Since this number of the *Journal* contains a rather full report of the Librarian of the Tennessee Academy of Science, it seems fitting at this time to introduce our Librarian to the members of the Academy. Miss Eleanor Eggleston, The Librarian of the Tennessee Academy of Science, was born and educated in Vermont. She was engaged in library work there as assistant and later as Head Librarian of a Public Memorial Library. Miss Eggleston was very active in the Vermont Library Association, holding office in the Association for a number of years. Since coming to Nashville, Tennessee, in 1920, she has been connected with the Library at Vanderbilt University in the capacity of Serial Cataloguer.