THE CLASSIFICATION OF GALVANIC SKIN REFLEX AFFERENT FIBERS*, †

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There are in cutaneous nerves three significant groupings of fibers. Of these, two consist of myelinated or A fibers, those of greater diameter being known as A-alpha fibers, those of lesser diameter A-delta fibers.[1] The third grouping consists of unmyelinated or C fibers. Among the afferent fibers of muscle origin there are four groupings, three of which consist of myelinated fibers which (in order of decreasing diameter and increasing threshold) are known as Group I, Group II, and Group III fibers.[2] Groups II and III correspond in general to the A-alpha and A-delta groups of cutaneous nerves respectively. In fact the latter have on occasion, particularly in relation to studies on reflexes, been called Group II and Group III fibers. The outstanding difference between muscular afferents and cutaneous afferents is the absence among the latter of Group I. Muscle nerves also contain afferent C fibers.

It is well known, particularly from the work of Wang,[3] that stimulation of a peripheral nerve gives rise to the galvanic skin reflex which signifies activity in sweat glands and which in the cat is readily recorded from the hairless pads of the feet.

The purpose of this study was to discover which of the fiber groups contain fibers afferent for the galvanic skin reflex. Cats were anesthetized with a mixture of chloralose (40 mg/kg) and urethane (0.8 gm/kg) administered by intraperitoneal injection. Zinc-zinc sulfate electrodes were placed one on the surface of the central foot pad, the other subcutaneously at a short distance from the first. These led to a dc amplifier and cathode ray oscillograph. The peroneal cutaneous nerve or sural nerve served as afferent channel from skin, the combined gastrocnemius, plantaris, and flexor longus nerves as afferent channel from muscle. These were fitted with stimulating electrodes and, where useful, with recording electrodes to monitor the afferent volleys.

Reflexes of Cutaneous Origin.—A fiber reflexes: Figure 1 contains the result of an experiment in which amplitude of the galvanic skin reflex was recorded as a function of the measured amplitude of afferent volleys confined to the A-alpha group of fibers in a cutaneous nerve. Reflex threshold is attained utilizing afferent volleys somewhat over 20 per cent of maximum. With increasing input the galvanic skin reflex output continues to increase until the input reaches maximum.

From the evidence in Figure 1, it is clear that a large fraction, at the least, of the A-alpha input is afferent for the galvanic skin reflex. That a volley of size between 20 and 40 per cent maximum is necessary to secure any reflex may mean that the lowest threshold fibers are not concerned with galvanic skin reflexes. However, as with other reflexes,[4, 5] it is only reasonable to suppose that there is need for central summation in order to secure a reflex result, and hence that even the largest fibers could be afferent for the reflex.

In Figure 2, galvanic skin reflex amplitude is plotted as a function of stimulus strength expressed as multiples of A-alpha fiber threshold. Again it is seen that the A-alpha fibers contribute to the securing of a reflex. Furthermore, it is seen that increase in the afferent stimuli to include the A-delta fibers causes a further increase in reflex amplitude. Apparently all parts of the A-delta fiber spectrum are active in producing a reflex discharge.

C fiber reflexes: Figure 3 illustrates the development with incrementing stimulation of C fiber galvanic skin reflexes. In record A, the stimulus strength was sub-

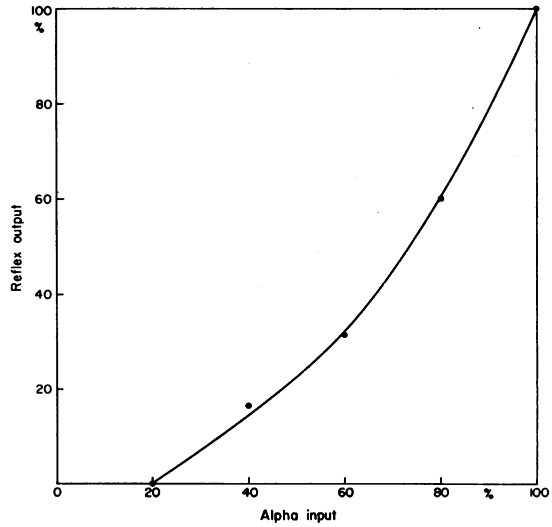

FIG. 1.—Input-output curve in the A-alpha range of a sudomotor reflex.

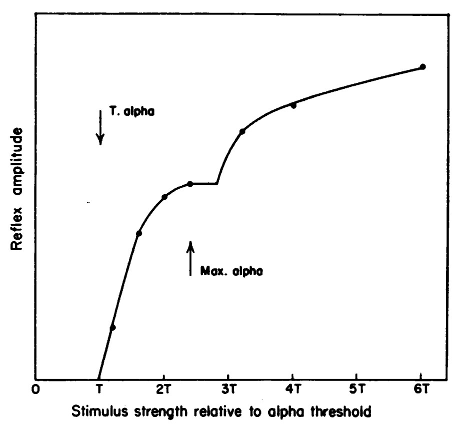

FIG. 2.—Sudomotor reflex amplitude as a function of stimulus strength set relative to A-alpha threshold. The two-part curve represents afferent contribution by the A-alpha and A-delta fibers.

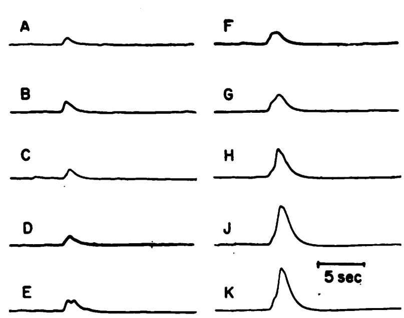

FIG. 3.—Sudomotor reflexes elicited by incrementing afferent stimulation in the range from submaximal A-delta to maximal C afferent input.

maximal for the A fiber reflex. The A fiber reflex is maximal in record B and in all subsequent records. The C fiber reflex first appears in record E and in the subsequent records increments to maximum. Latency of the C fiber reflex is longer than that of the A fiber reflex, causing a two-part rising phase to the over-all response as recorded. As in the experiment presented, the C fiber component of the response is considerably the larger of the two when cutaneous nerves serve as afferent channels.

It is possible to compare the spectrum of afferent channels for the galvanic skin reflex with those for another autonomic reflex, the pupillo-dilator reflex. The latter have been determined by Evans,[6, 7] who finds the A-delta and C fibers to contain the entire afferent input, with the C fibers being by far the more potent. Although it is difficult to say what relationship there may be between the afferent fibers that subserve these reflex effects and those mediating the various sensory modalities, it is reasonable to suppose that the A-delta and C fiber reflexes are nociceptive in nature. If, on the other hand, the A-alpha galvanic skin reflex were nociceptive, there would seem to be no reason why the A-alpha fibers in action should not cause pupillo-dilatation as well. There is then some reason if not a compelling one to suppose that fibers subserving some modality other than pain are capable of eliciting the galvanic skin reflex on stimulation of ordinary cutaneous nerves. Warmth-mediating fibers seem to be the obvious candidates for action in generating the A-alpha galvanic skin reflex. Indeed, Wang and Brown[8] assume that impulses in fibers from warmth receptors as well as pain receptors elicit the galvanic skin reflex.

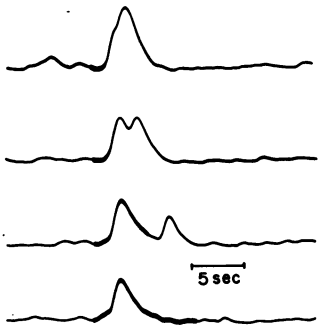

FIG. 4.—Sudomotor reflexes elicited by stimulus trains of incrementing duration applied to muscular afferent fibers. Widening of the traces caused by stimulus artifacts. Stimulus strength maximal for C afferent fibers.

Reflexes of Muscular Origin.—When muscular afferent fibers are stimulated, there is no sign of a reflex until the strength of stimulation is increased to embrace the Group III fibers. On repeated trials, Groups I and II fibers have been quite ineffective, and one must suppose that they are devoid of connection to the spinal sweat mechanism.

On raising the stimuli to C strength, there is a further increase in the size of the reflex, but the increment is not as great as it is when cutaneous nerves serve as afferent channels. Some idea of this can be obtained by comparing the top record in Figure 4 with record K of Figure 3. The discontinuity on the rising phase of the recorded reflex response which differentiates the C fiber reflex from the A fiber reflex is much closer to the apex of the response when muscle afferent fibers are stimulated than it is when cutaneous afferent fibers are stimulated. This bespeaks the paucity of C fibers in muscle nerves.

Terminal rebound: Figure 4 presents a series of records in which the galvanic skin reflex results of tetanizing the muscle afferent input are shown. From above downwards, the durations of stimulation were 1, 2, 5, and 10 seconds. The C fiber component is seen to emerge progressively later as the stimulus duration is increased. After the 10-second stimulus, however, the C fiber component fails to appear at all.

Latency of the C fiber component is fixed by the end of the stimulation however brief that stimulation may be. Presumably, then, when it appears, it is an off-response whatever the stimulus duration, even the briefest.

Wang and Brown[8] were the first to describe the terminal rebound and, except for the fact that it is seen after stimulation of purely muscular nerves, the present experiments confirm theirs in essence. It is agreed that afferent C fibers must be active for the effect to appear. Another condition seems to be that the C fiber reflex must fall during the course of the A fiber reflex; otherwise, the C fiber reflex is inhibited as in the last record of Figure 4.

Wang and Brown[8] discuss the terminal rebound effect in terms of inhibition of the C fiber reflex during the period of stimulation by activity of larger cold-receptive fibers. However, as here shown, the effect is present when stimulation is confined to muscular afferent fibers (Figure 4), which means at the least that it is not specifically related to the action of cold-receptive fibers.

In the classical view, terminal rebound is a sign of concealed inhibition with excitatory effects outlasting the inhibitory to produce a response at the close of stimulation. As this seems the only explanation, it is probably correct to conclude, with Wang and Brown, that there exists an inhibitory reflex although one cannot specify the executant afferent pathway.

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NEURONAL EXTENSION AND GLIAL SUPPLY: FUNCTIONAL SIGNIFICANCE OF GLIA

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Our knowledge concerning the functional significance of glia cells is still insufficient. The present study represents an attempt to correlate the number of glia cells with known morphological features (length of axon) of neurons. Clark's column in the spinal cord provided an opportunity to compare the glial supply of