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Single presynaptic impulse evokes postsynaptic discharge

From the study of stimulus:response relationships along central ascending pathways of the cat, strong evidence has been gained that a single impulse produced in a single cutaneous afferent can evoke a unitary or multiple postsynaptic discharge in cells of the dorsal spinal gray matter.

Extracellular microelectrode recordings (2.7 *M* KCl- or 4 *M* NaCl-filled micropipettes) were made from cells of laminae 4 through 6 in decerebrate, high or low spinal cats which were initially anesthetized with fluothane. Two kinds of cells which were synaptically connected with myelinated cutaneous afferents were observed, those having one type or several types of skin afferents converging upon them (*e.g.*, Types T, G and D hairs and Types I and II skin[3]). The cells that were connected with a single type of skin afferent are of most importance for this communication and of these, the cells that were connected to the tactile pad afferents of hairy skin (Type I[2,8,9]) are of most interest. Several of these cells have been studied in which a synaptic convergence of primary sensory units was noted. In one example, 18 contiguous tactile pads which represent, on the average, 6 adjacent primary receptive fields[9] were found to elicit a postsynaptic response. In other instances, 2 or 3 active primary sensory units were found separated on the skin by inactive units. In all cases a very high synaptic security was found between the tactile pad afferents and the postsynaptic cells.

Three kinds of evidence can be used to validate that postsynaptic events were being studied. First, the number and distribution of active tactile pads on the skin indicate a convergence of several primary sensory units. The primary units are composed of from 1 to 7 pads and have non-overlapping peripheral receptive fields[9]. Second, electrical stimulation of the intact dorsal rootlet, which contains the axon of the primary afferent, produces a response with a latency greater than 0.8 msec. This latency is longer than could be accounted for if recordings were being made from the presynaptic terminals. And third, the cell follows sinusoidal mechanical stimulation of the receptor for only a limited number of impulses and rapidly habituates to consecutive stimulus applications (Fig. 1A). In contrast, the primary afferent can follow these stimuli, one-for-one, for at least 1024 impulses[5].

In cat, more than 95% of the tactile pads is innervated by one myelinated fiber which is distinct from that which supplies the tylotrich hair which often accompanies the pad[2,7,9]. Therefore, mechanical stimulation of a single pad is likely to evoke a response in only a single innervating myelinated fiber. The pad and its imbedded receptor apparatus are highly insulated from surrounding skin. While a single action potential can be evoked by direct pad stimulation with a short mechanical pulse of 2–10 μ amplitude (rise time 2 msec; total duration 3 msec)[9], a stimulus 10–100 times as intense is required to elicit such a response when the stimulus probe is placed less than 1 mm away from the pad. Similarly, the receptor responds sensitively to vibratory stimuli of long duration and high frequency[5] when directly applied to the pad, but is unresponsive to much higher amplitude vibratory stimuli applied to adjacent skin.

While recording from a postsynaptic cell, a short duration mechanical stimulus was applied to each tactile pad within its receptive field and to adjacent hair and skin

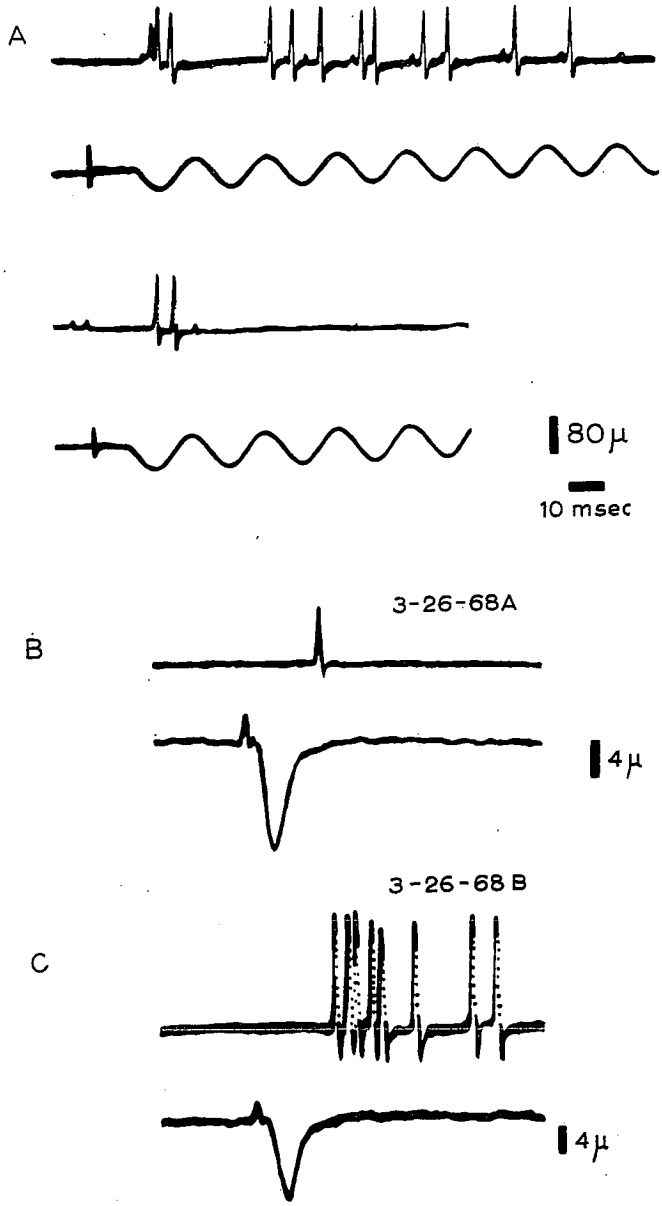

Fig. 1. A, Response of postsynaptic cell to the first and fifth stimuli applied to tactile pad afferent within its receptive field. Sinusoidal mechanical stimuli consisted of groups of 16 cycles at 50 c/sec applied every 2 sec. B and C, Single and multiple postsynaptic discharge in response to threshold mechanical stimulus of short duration applied to single tactile pads. In each pair, upper trace is pulses from discriminator circuit and lower trace is monitor of movement of mechanical stimulator. Records untouched.

structures. A single or multiple discharge was obtained when a 2–10 μ displacement was applied directly to the pads (Fig. 1B and C). The response latency indicates that

only a myelinated fiber was involved. No response was elicited by stimulating tylotrich hairs or other structures in the close vicinity of the pads even with amplitudes of 100 μ. Since the activating stimulus applied to the pad was of threshold intensity for producing but a single action potential in the primary afferent, we conclude that a single action potential produced in a single axon of a cutaneous afferent can evoke a postsynaptic discharge and that, on occasion, an amplification in the form of a multiple response can be obtained. The multiple discharge appears similar to that observed for Renshaw cells and for cells of the dorsal column nuclei and may reflect prolonged depolarization of the postsynaptic cell[1]. The synaptic properties of these dorsal quadrant connections contrast sharply with those of the motoneuron where spatial and close temporal summation appear to be required to obtain a propagated response[4,6]. A more complete report of the organization and synaptic properties of the cells of the dorsal gray is in preparation.

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