Reflexes in Postganglionic Fibres within Skin and Muscle Nerves After Noxious Stimulation of Skin*

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Summary. 1. Somato-sympathetic reflexes in postganglionic neurones to skin and muscle induced by noxious stimulation of skin were studied in cats anaesthetized with chloralose. The reflexes were elicited by mechanical damaging stimuli and by temperature stimuli of more than 45°C.

2. In most cutaneous units the spontaneous activity was depressed during noxious stimulation of skin. Some cutaneous units were excited or showed mixed responses. The depression of the spontaneous activity was maximal from the skin area which was innervated by the cutaneous postganglionic neurones and much weaker or not elicitable from other skin areas.

3. Most muscle units were excited during noxious stimulation of skin. This excitation could be elicited from all over the body surface.

4. The effective cutaneous afferent fibres which are involved in these reflexes are the Group III axones which are excitable by mechanical damaging stimuli and the Group IV axones which are excitable by mechanical damaging and/or by thermal noxious stimuli.

5. These investigations reveal that the somato-sympathetic reflexes have opposite organization in cutaneous and muscle postganglionic fibres. The reflex patterns are discussed in relation to a possible central organization of the sympathetic nervous system.

Key words: Somato-sympathetic reflexes — Cutaneous and muscle postganglionic neurones — Noxious stimulation of skin — Cat

High frequency electrical stimulation of thin myelinated and low frequency stimulation of unmyelinated cutaneous afferent fibres produces increase of blood pressure and remarkable excitatory responses in sympathetic nerves (for literature see Koizumi and Brooks, 1972; Sato and Schmidt, 1973). It is accepted that these excitatory effects on the sympathetic nervous system originate from stimulation of cutaneous nociceptive afferent fibres.

In this paper reflexes in cutaneous and muscle postganglionic fibres elicited by natural stimulation of cutaneous nociceptors will be reported. The reflexes were elicited by two types of stimuli: mechanical damaging stimuli and temperature stimuli of more than 45°C.

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Methods

The general experimental procedures were similar and the populations of postganglionic fibres investigated were practically identical to those in the preceding paper (Horeyseck and Jänig, 1974).

With a toothed forceps noxious mechanical stimuli were applied to the digits of both hindfeet and of the contralateral forefoot. These stimuli are supposed to excite cutaneous mechano-nociceptors innervated by Group III and Group IV afferent fibres (Burgess and Perl, 1967; Perl, 1968; Besson and Perl, 1969). The stimuli lasted for 2 to 10 sec. Throughout all experiments they were applied manually by the same experimenter to the hairy skin of the digits about 0.5 cm proximal to the non-hairy skin. The beginning of the oscilloscope sweep was signalled by a short click. In this way the beginning of the stimuli varied by less than ±100 msec. The stimuli were applied at repetition rates of 1 per 30 to 40 sec. Since the four digits were pinched consecutively the mechano-nociceptors in the skin of one digit were excited every 2 to 2 min and 40 sec.

Cold-, warm- and heat-receptors (Iggo, 1959; Witt and Hensel, 1959; Hensel et al., 1960; Iriuchijima and Zotterman, 1960; Douglas and Ritchie, 1962; Hensel, 1966; Bessou and Perl, 1969) were excited selectively by immersing the foot of the contralateral hindlimb in water of 15°C to 58°C. The temperature of the water was measured with a thermometer. The temperature was raised and decreased in steps of 10 to 40 degree centigrade and of 1.5 to 3 min duration by exchanging the water. This exchange was accomplished in less than 10 sec. With high temperatures of more than 45°C the temperature of the water fell about 1 to 2 degrees centigrade during a temperature step at ambient room temperature of 25 to 28°C.

Results

1. Reflexes in Cutaneous Postganglionic Neurones

The effects of noxious stimulation of skin on cutaneous postganglionic fibres are illustrated in Fig. 1. The filament recorded from contained between 12 and 18 postganglionic fibres (as estimated from a record of filament activity after stimulation of the lumbar sympathetic trunk) with a total spontaneous activity of 32 imp/sec (dashed line). Noxious mechanical stimuli (black bar in Fig. 1A) applied to the digits of the ipsilateral hindlimb depressed the spontaneous activity to 30–50% of its normal value. After the end of stimulation the spontaneous activity remained reduced for more than 11 sec.

Temperature stimuli of more than 45°C applied to the skin of the foot of the contralateral hindlimb (upper record in Fig. 1B) also reduced the spontaneous activity in the cutaneous postganglionic fibres (lower record in Fig. 1B).

Table 1. Quantitative analysis of the reflexes in postganglionic neurones to skin and muscle following stimulation of cutaneous nociceptors. For further Details see methods of Horeyseck and Jänig (1974)

<table>
<thead>
<tr>
<th>Postganglionic fibres to</th>
<th>Noxious stimulus</th>
<th>Total number investigated</th>
<th>+</th>
<th>+—</th>
<th>——</th>
<th>—</th>
<th>ø</th>
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<td>skin . . . . . .</td>
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<td>50</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>thermal</td>
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<td>8</td>
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<td>0</td>
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<td>13</td>
</tr>
<tr>
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<td>mechanical</td>
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<td>27</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>thermal</td>
<td>29</td>
<td>26</td>
<td>0</td>
<td>0</td>
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