The Influence of Temperature on the Activity of Spinal α- and γ-Motoneurons

In 1955 BROOKS et al.[1] reported that cooling of the spinal cord of cats was followed by an augmentation of spinal reflexes. In 1963 SIMON et al.[2] found that moderate local cooling of the dog's spinal cord resulted in shivering with increased oxygen consumption. So far nothing has been known about the effects of temperature on the spontaneous activity of spinal α- and γ-motoneurons.

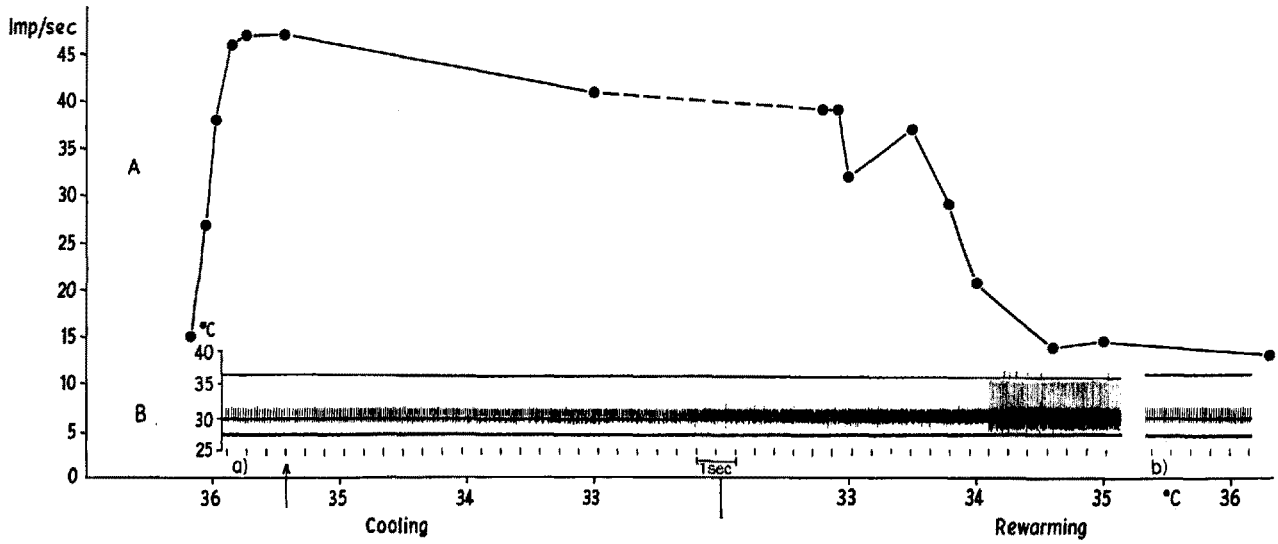
Cats were anaesthetized with barbiturate (Pernocton, 40–50 mg/kg). Cooling of the spinal cord was achieved by an U-shaped polythene tube through which water of different temperatures could be circulated. The polythene tubing was pushed into the vertebral canal through a hole in the sacral bone such that the tip of the tubing was within the lower third of the thoracal region. The tubing was connected by a four-way stop-cock to three thermostats in which the water was held constant at 16, 37–39 and 45°C respectively. The ambient temperature of the laboratory was kept between 28 and 30°C. The activity of α- and γ-motoneurons was recorded from thin filaments of the ventral roots of L_6 to S_1.

Moderate cooling of the spinal cord usually resulted in an increase in γ-motoneuron activity. Either new γ-motoneurons were activated by lowering the temperature, or the frequency of spontaneous firing neurons was increased. In most of the cases this increase occurred within a few seconds after the onset of cooling and before any shivering was visible. During this time the actual temperature of the spinal cord had changed by only a few tenths of a degree. If the anaesthesia of the animal was not too deep, α-motoneurons could be activated as well, but the increase in γ-motoneuron activity always preceded that of the α-motoneurons. A typical example of such a response is shown in the inset B of the Figure (part a).

During cooling the frequency of both the α- and γ-motoneurons usually showed some adaptation, as can be seen for the γ-activity from the curve A of the Figure. In a very few cases the α- and γ-motoneuron activity returned to precooling levels while the cooling was still going on.

Rewarming of the spinal cord was followed by a return of α- as well as γ-motoneuron activity to precooling levels (Figure, curve A and inset, part b). In some cases the γ-activity did show a transitory increase during rewarming. This seems to be an indication that the change of temperature as well as the absolute level of temperature does have an effect on the spontaneous activity of the motoneurons.

If the temperature was raised above the normal range, spontaneous firing γ-motoneurons could be suppressed. This suppression occurred at temperatures between 39 and 41°C on the surface of the spinal cord. On returning to prewarming temperatures the spontaneous activity was re-established.



Spontaneous α- and γ-motoneuron activity during local cooling of the cat's spinal cord. A, Upper curve: The γ-motoneuron activity of a small ventral root filament (ordinate) plotted against the temperature on the surface of the spinal cord (abscissa). B, Inset: Upper trace: temperature on the surface of the spinal cord. Middle trace: motoneuron activity within the same ventral root filament. Lower trace: muscle activity by electromyography. a) Initial phase of cooling; arrow indicating onset of cooling. b) After returning to precooling temperatures.

Zusammenfassung. Lokale Kühlung des Rückenmarks bei Katzen in Barbituratnarkose führte zu einer Steigerung der Aktivität sowohl der α- als auch der γ-Motoneurone, die durch Wiedererwärmung wieder rückgängig gemacht werden konnte. Die Schwelle für diese Aktivitätssteigerung lag bei den γ-Motoneuronen niedriger als bei den α-Motoneuronen. Erwärmung über die Ausgangstemperaturen unterdrückte eine bei normaler Temperatur vorhandene Spontanaktivität der γ-Motoneurone.

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[1] C. McC. BROOKS, K. KOIZUMI, and J. L. MALCOLM, J. Neurophysiol. *18*, 205 (1955).

[2] E. SIMON, W. RAUTENBERG, R. THAUER, and M. IRIKI, Naturwissenschaften *50*, 337 (1963).