ment de la tension musculaire, un allongement du tronc et un rétrécissement de son diamètre (spectaculaires chez *Turbanella hyalina* Schultze) – accompagnés d'un accroissement de la fragilité des animaux. Une concentration double de celle de l'eau de mer provoque l'éclatement de plusieurs espèces (dont *Neodasys chaetonotoideus* Remane). Un taux faible de $MgCl_2$ peut aussi avoir un effet anesthésique, mais extrêmement lent et parfois imparfait.

(2) *Le sulfate de Magnésium* (*$MgSO_4$*). Son effet a été testé sur la seule *T. hyalina* Schultze et à la concentration de 20% dans l'eau de mer et l'eau douce.

(3) *Le Méthane sulfonate* (*MS 222 Sandoz*). Le Méthane sulfonate de l'ester éthylique de l'acide *m*-aminobenzoïque (MS 222) est un anesthésique réversible ayant permis l'obtention de résultats intéressants et la réalisation d'interventions physiologiques délicates sur un certain nombre d'animaux à sang froid, et notamment sur les Poissons. L'un des principaux intérêts du MS 222 est sa faculté d'action sous forme de bains.

Dans le cas des Gastrotriches marins, ce produit est inactif pour une très faible concentration dans l'eau de mer (1/6000 ou moins); à une concentration plus élevée, l'effet est très lent et la décontraction moins parfaite qu'avec le $MgCl_2$; à concentration supérieure à 1/4000, les animaux demeurent trop contractés pour pouvoir être commodément étudiés; pour une concentration élevée (1/1000), si l'anesthésie est très rapidement réalisée, les résultats sont aussi peu favorables. Dans le cas des Gastrotriches d'eau douce, nous n'avons expérimenté qu'avec une concentration de 1/1000 dans l'eau douce, et sur 2 espèces: *Lepidoderma squammatum* Dujardin et *Chaetonotus maximus* Ehrenberg.

(4) *Le Flaxédil*. Ce composé est un Triodoéthylate de gallamine (curare), dont nous avons testé l'effet sur 3 Gastrotriches marins: *T. cornuta* Remane, *T. digitifera* d'Hondt et *Xenotrichula cornuta* Wilke.

(5) *La Xylocaïne*. Cet anesthésique local de synthèse, succédané de la cocaïne, est à base de chlorhydrate de diéthylamino 2–6 diméthyl acétinilide.

Nos expériences ont porté, dans le cas des Macrodasyoides, sur 3 espèces (*T. cornuta* Remane, *Dactylopodalia weilli* d'Hondt et *Thaumastoderma swedmarki* Levi); nous avons utilisé la solution pharmaceutique à 0,1% qui nous a paru trop diluée. A faible dose, l'effet semble variable. A forte dose et pour un très important volume de Xylocaïne, l'effet anesthésique est assez rapide, mais les animaux demeurent plus ou moins contractés (notamment dans le cas de *T. swedmarki*); il est vraisemblable que cette substance intervient à la fois par les constituants en solution et par la nature de sa phase liquide (eau douce, qui contribue à abaisser la teneur en NaCl de l'ensemble). La «mise en boule» est générale et instantanée sur les *Chaetonotus* d'eau douce. Dans le cas d'un Chaetonotoide marin, les résultats sont satisfaisants pour un volume de Xylocaïne très supérieur à celui de l'eau de mer (et l'anesthésie est extrêmement lente).

Summary. The effects of anaesthesia on contraction of some species of marine and freshwater gastrotrichs have been studied with various substances ($MgCl_2$, $CaCl_2$, MS 222, Flaxedil, Xylocaïne).

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The Acceleration Response of a Primary Muscle-Spindle Ending to Ramp Stretch of the Extrafusal Muscle

To determine the measuring properties of a muscle-spindle primary ending, a ramp stretch is usually applied to its extrafusal muscle, pulling it to a definite length with a constant velocity. It is well known that the primary ending's response shows a frequency peak at the end of the dynamic phase of stretch, followed by a frequency decrease to a lower static value at the maintained new length. However, in many cases an additional discharge burst can be observed shortly after the start of the stretch. The present communication is concerned with the nature of this initial frequency peak which is still controversial in the recent literature.

Conventional methods were used for producing ramp stretches of a hindlimb extensor muscle in anaesthetized cats and for recording the instantaneous discharge frequency of a primary spindle ending located within the same muscle (detailed description[1]). Fig. 1 shows the characteristic discharge pattern before and during a stretch whose velocity in this case was 30 mm/sec and its length was 12 mm. The sequence of dots gives the instantaneous frequency of the spindle discharges. The frequency jerks at the beginning of the stretch from the 'spontaneous' activity up to an initial burst (A) and then drops. It rises again to a maximum (D) at the end of the stretch. From (D), the frequency drops steeply at first and then gradually decreases to the value of the static response (S). It is known that from this curve the spindle's sensitivity to length and velocity of the muscle movement can be read. The spindle measures the length by the so-called static response, which is defined as the activity in the second half of the first second after the end of stretch[2] minus the spontaneous activity[1,3]. The velocity of stretch is measured by the dynamic response, which is defined as the difference between the maximum (D) at the end of the dynamic phase of stretch and the static response (S). At a constant velocity, this response ought to be independent of stretch length. However, with short stretches of 2–4 mm, the apparent dynamic response – as measured in the conventional way – was markedly higher than in the range of stretch lengths of 4–12 mm, because it now coincided with the initial burst (A). The initial burst can be observed regularly with low or absent fusimotor innervation, whereas it often becomes smaller with enhanced γ-innervation.

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[1] SONJA S. SCHÄFER and H.-D. HENATSCH, Expl Brain Res., in press (1967).

[2] A. CROWE and P. B. C. MATTHEWS, J. Physiol. *174*, 109 (1964).

[3] S. S. SCHÄFER and H.-D. HENATSCH, Pflügers Arch. ges. Physiol. *294*, 78 (1967).

The initial burst appears in the characteristic primary-ending discharge pattern as the velocity of stretch rises from zero value to the constant value or, in other words, as the extrafusal muscle is accelerated to the velocity of the stretcher. Therefore, we assumed that the spindle measures this acceleration with the initial burst (A). Ten experiments were performed in order to determine whether the height of the initial burst was a function of acceleration.

Fig. 2 shows the results of such an experiment. The velocity of stretch is indicated on the abscissa; the range of velocities used was 10–360 mm/sec. The time necessary for the stretcher to reach its final velocity was kept constant at about 20 msec. So the net acceleration is given by the velocity value divided by 20 msec. The size of the initial burst in imp/sec is indicated on the ordinate. The curve shows a linear course in the higher velocity range but an approximately logarithmic dependency in the lower range (75–0 mm/sec). Thus, the size of the initial burst (A) was indeed found to be dependent upon the acceleration of the stretcher and may in the following be referred to – in a descriptive sense – as the 'acceleration response'.

In other experiments, the velocity was not kept constant throughout the stretch; after the muscle had been stretched about 4 mm with a velocity of 1–15 mm/sec, the velocity of stretch was suddenly increased to 55 mm/sec. With the momentary change of velocity (acceleration), a renewed acceleration response was observed. In similar experiments, the extrafusal muscle was stretched in a stepwise manner, the ramp stretch being stopped after a few mm for some fractions of a second before it was continued to a greater length. A new acceleration response appeared at the foot of each step. Other experiments involved stretching of the extrafusal muscle from different prelengths. The latency and the height of the acceleration response were found to be constant and independent of prelength provided that the recorded spindle remained in the direction of pull of the stretcher. Just as the spindle indicates positive acceleration by the initial burst, it shows negative acceleration (a decrease in velocity/Unit time) by a few frequency points at the end ofthe dynamic phase which are lower than the following points (see Fig. 1). However, this negative acceleration response has been found to be much smaller than the positive acceleration response which corresponds to theoretical expectations[4].

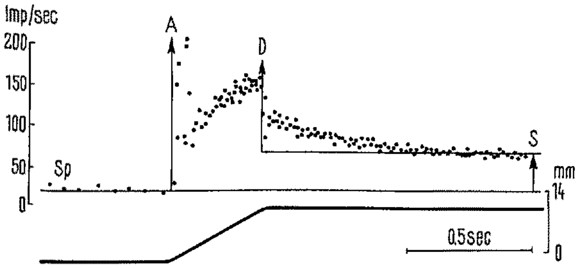

Fig. 1. The discharge pattern of a muscle spindle primary ending during ramp stretch of the extrafusal muscle.

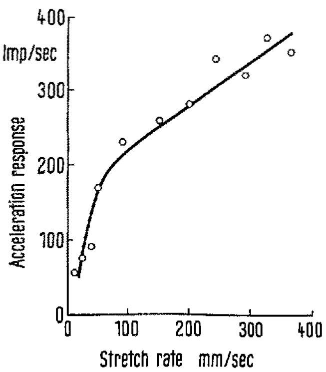

Fig. 2. The height of the acceleration response in Imp/sec is plotted against the stretch velocity (see text) in mm/sec. The relation between the 2 variables is approximately logarithmic when the velocity is 0–75 mm/sec and linear when the stretch velocity is 75–360 mm/sec.

In the recent literature, the initial burst has been noticed only by LAPORTE[5], who did not pay much attention to the phenomenon, and by MATTHEWS[2]. This author interpreted it as a consequence of static frictional force. According to this interpretation, the muscle spindle sticks to its surroundings for a short time before it follows the stretch of the extrafusal muscle. To overcome the static friction a constant force, independent of the succeeding velocity, would be required. However, the curve shown in Fig. 2 indicates that the size of the burst is dependent on velocity.

The genesis of the acceleration response can be simply explained by considering that the spindle is located in vivo within the large extrafusal muscle. Thus, the external ramp stretch is first transferred to the extrafusal muscle which in turn transfers the distortion to the intrafusal bundle. So we have 2 transfer components in series, each of which possesses elastic as well as viscous structural elements. The elastic elements lead to proportional transfer behaviour, while the viscous elements lead to differential (or derivative) transfer behaviour. Neglecting all possible non-linear complications, this means that apart from 2 proportional transfer steps, the original length change undergoes 2 successive differentiating steps. By definition, a twofold differentiation of length against time is an acceleration.

On this basis, a mathematical model can be formulated which takes into account not only the qualities of the intrafusal fibres (as was done by previous workers[6,7]) but also the properties of the extrafusal muscle. It will be shown elsewhere[4] that this model predicts not only a velocity and length sensitivity but also an acceleration sensitivity of the primary ending of a muscle spindle imbedded in its extrafusal muscle.

Zusammenfassung. Bei einer rampenförmigen Dehnung des extrafusalen Muskels signalisiert die primäre Muskelspindelafferenz nicht nur Länge und Geschwindigkeit, sondern auch Beschleunigungen. Die Beschleunigungsantwort entsteht durch zweimalige Differenzierung der Länge nach der Zeit infolge der viscösen Eigenschaften des Extrafusalmuskels und des intrafusalen Bündels.

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