EFFECT OF STIMULATION OF DIFFERENT PARTS OF THE BRAIN STEM ON REFLEX ACTIVITY OF A GROUP OF SPINAL CORD EXTENSOR MOTONEURONS

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It was shown by recording focal and root responses to stimulation of the nerve to the gastrocnemius muscle that stimulation of different brain stem structures causes descending excitatory, inhibitory, and mixed effects, and that all these types of responses can be obtained from the same center.

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The object of this investigation was to study descending influences arising during stimulation of various structures of the medulla.

The character of suprasegmental influences on reflex activity of a group of extensor motoneurons was assessed from changes in the monosynaptic potential of the ventral root and in the focal potential of the ventral horn. It has been suggested [2, 3] that by combined recordings of these potentials, changes arising during activation of suprasegmental structures can be studied not merely in discharging motoneurons, but also in subthreshold-activated motoneurons.

EXPERIMENTAL METHOD

Experiments were carried out on unanesthetized, curarized cats. Reflex monosynaptic responses of a group of extensor motoneurons were produced by single (1/sec) threshold stimulation of the nerves to the gastrocnemius muscle. Focal potentials of the motoneuron nucleus were recorded by metallic electrodes with a tip 30-40 μ in diameter. Reflex potentials were recorded from the 7th ventral root by means of silver electrodes. Stepwise (0.5-6 V) stimulation (150-200/sec) of the medullary structures was applied through metallic electrodes similar to those used for recording. The position of the electrodes was verified by microelectrolysis [4], followed by preparation of serial brain sections and identification from the atlases of Grantyn' [1] and Rexed [10].

EXPERIMENTAL RESULTS

Activation of various areas within the lower two-thirds of the rhomboid fossa on both ipsilateral and contralateral sides was accompanied by a variety of changes in the reflex responses of the motoneuron center for the gastrocnemius muscle. On this basis, four functionally different structures were distinguished (Table 1). It will be clear from Table 1 and Fig. 1 that within the limits of this area of the rhomboid fossa topographic overlapping of functionally heterogeneous structures takes place. For this reason it is impossible to draw a sharp line between areas giving responses of different character [7, 8]. At the same time, however, in contrast to information given by other authors [11], our results do not support a completely diffuse distribution.

Suprasegmental responses arising from the different structures varied in threshold, magnitude, and development with time.

Facilitation from the rubro- and vestibulospinal tracts, the vestibular complex, and gigantocellular nucleus developed as an immediate response to stimulation even of low intensity. Facilitation from the parvocellular and ventral nuclei appeared in response to stimulation of lower intensity and was less marked.

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TABLE 1. Descending Responses Arising during Stimulation of Various Medullary Structures

Morphological structure	Character of descending response								
	from ipsilateral side					from contralateral side			
	facilitation	inhibition	no change	mixed	short-latency	facilitation	inhibition	no change	mixed
Ventral nucleus (Rv)	12	9	1	2	1	3	3	1	1
Parvocellular (Rpc)	8	5	6	8	–	3	2	2	2
Paramedian (Pm)	1	2	4	1	–	–	–	2	–
Gigantocellular (RGc)	18	9	4	7	5	3	2	1	1
Rubrospinal tract (TRS)	4	1	–	1	9	1	–	–	–
Vestibulospinal tract (TVS)	7	–	–	1	5	4	–	–	1
Nucleus of trigeminal nerve (NtspV)	2	–	2	–	1	–	–	–	–
Predorsal fasciculus (Fprd)	–	1	–	–	1	–	2	1	–
Vestibular spinal nucleus (VIIIsp)	4	–	–	1	2	1	–	–	–
Fasciculus solitarius (nfs)	3	–	–	–	2	–	–	–	–
Vestibular nucleus of Schwalbe (VIIIm)	3	–	–	–	2	–	–	–	–
Total	59	27	20	21	26	15	9	7	5

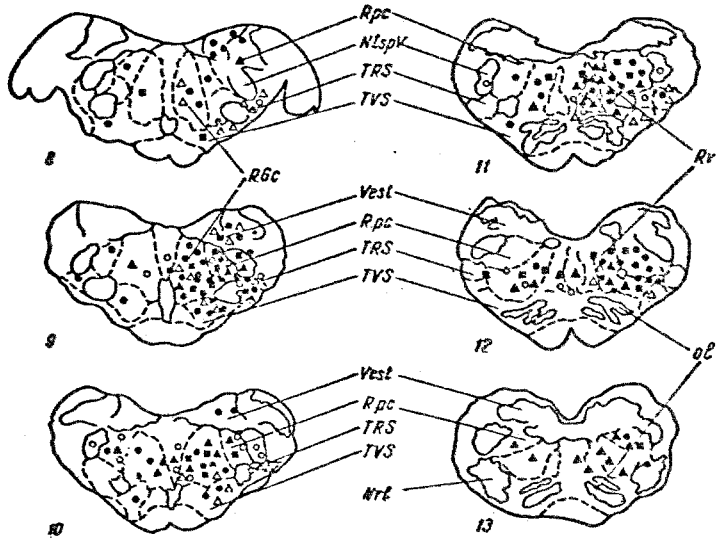

Fig. 1. Diagram showing localization of stimulation and nature of descending responses. 8-13) Diagrams representing frontal sections through brain stem; points are shown, stimulation of which was accompanied by increased reflex responses (black circle), by inhibition (black triangle), by absence of changes (unshaded circle), by a mixed effect (black square), and by short-latency facilitation (unshaded triangle). Numbers denote serial numbers of sections according to Grantyn's atlas [1]. Symbols denoting morphological structures in medulla identical with those in Table 1.

Amplitude of the response reached its maximum at the end of stimulation, and this was followed by an after-effect persisting for between 10 and 30 sec.

In most cases (42 points) descending facilitation was manifested by an increase in the focal potential and monosynaptic spike (Fig. 2B). Sometimes (12 points) an increase of 3-4 times in the monosynaptic potential corresponded to a decrease of 1.2-2 times in the amplitude of the focal potential (Fig. 2C). Less frequently (5 points) a small increase in the monosynaptic discharge in the ventral root took place with no change in the focal potential (Fig. 2A).

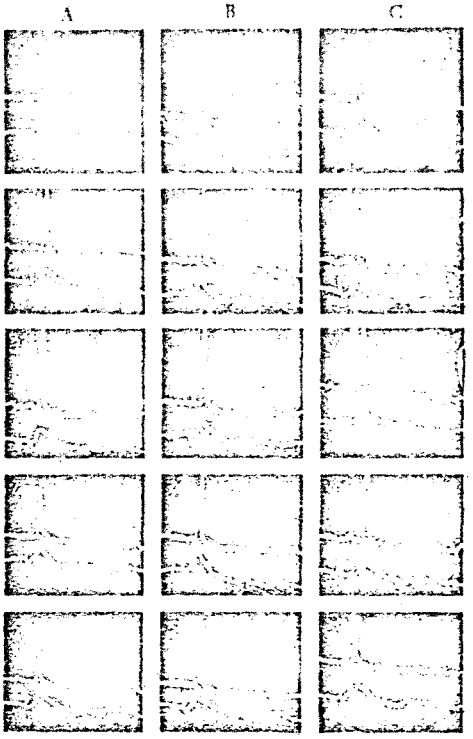

Fig. 2. Different variants of manifestation of descending facilitation. A) Facilitation manifested by increase in monosynaptic spike only; B) facilitation manifested by an increase in monosynaptic spike and focal potential; C) facilitation manifested by increase in monosynaptic spike and decrease in focal potential. 1) Potentials of ventral root (top beam) and ventral horn (bottom beam) under normal conditions; 2-4) at 3rd, 7th, and 10th second of suprasegmental stimulation; 5) after stimulation.

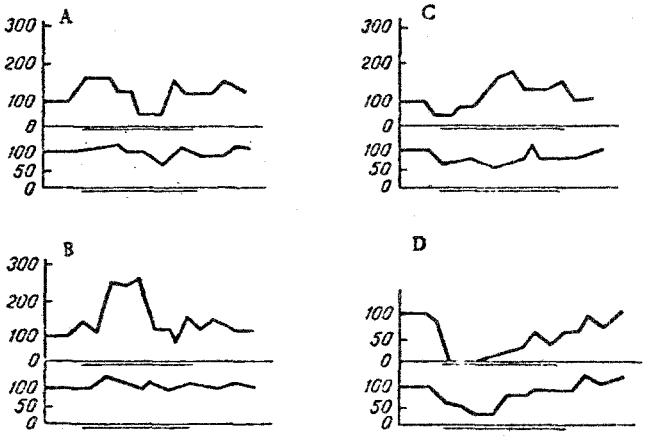

Fig. 3. Descending influences of mixed type and their changes with an increase in intensity of suprasegmental stimulation. A, C) Responses of mixed type to stimulation by a current of 1 V; B, D) responses of mixed type to stimulation by a current of 5 V. Ordinate: changes in monosynaptic spike (top part of graph) and focal potential (bottom part of graph) in percent of normal during suprasegmental stimulation: initial value of potentials taken as 100%; abscissa: time (in sec).

Depression of the reflex responses during stimulation of the ventral and gigantocellular nuclei took place immediately after stimulation began. The period of after-inhibition was ill defined or absent. Inhibition from the parvocellular and rostral part of the gigantocellular nucleus was maximal when stimulation of greater intensity was used and was found at the end of the stimulation which was followed by an inhibitory aftereffect.

Suprasegmental inhibition, like facilitation, was manifested by changes of varied character in the focal and monosynaptic potential. It has been suggested [3] that divergent changes in these potentials may be attributed to dissimilar changes in the zone of discharging and subthreshold-activated mononeurons associated with descending responses of different magnitudes.

The appearance of mixed responses from the parvocellular nucleus was evidently due to the fact that its activation effect is brought about through inhibitory and facilitatory structures in other brain formations. Mixed responses from the gigantocellular nucleus probably arose when the electrode was located in the boundary region between inhibitory and facilitatory structures. This is confirmed by the fact that when the intensity of stimulation was increased, one type of descending response began to predominate (Fig. 3). Mixed descending responses have also been described by other authors [9].

Descending responses manifested by short-latency (6-9 msec) responses in the ventral horn and ventral root as a rule appeared during stimulation (200/sec) of the vestibulo- and rubrospinal tracts. The short latent period between each suprasegmental stimulus and the potentials in the ventral horn and root suggests that the descending impulses are conducted along disynaptic, or even monosynaptic, pathways [5,6].

This type of suprasegmental response should evidently be regarded as a variant of descending facilitation [3].

Suprasegmental responses of uniform character thus possess several distinguishing features which may be due to differences in the connections between the suprasegmental structures and the spinal cord neurons. It may be postulated that structures giving rise to well defined responses arising during weak stimulation play a fundamental role in regulation of the activity of the segmental apparatus and exert direct control over the spinal cord neurons. Structures giving only slight responses and only when strong stimulation is applied, followed by an aftereffect, evidently play the role of specialized "triggering" devices and have no regulatory significance of their own. Descending influences from these structures are probably mediated through other elements in the same, or even in different reticular formations.

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