

EFFECT OF THE SUPERIOR COLLICULUS ON FUNCTION OF THE CONTRALATERAL LATERAL GENICULATE BODY IN CATS

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Relations between different parts of the central visual system and, in particular, the lateral geniculate body (LGB) and superior colliculus (SC), have attracted the attention of research workers for a long time. However, whereas geniculocollicular relations have been studied in sufficient detail, colliculogeniculate relations have received much less attention. Nevertheless, the view has been expressed [8, 9] that these relations must play an important role in the organization of the effect of saccadic suppression of LGB function, without which visual perception would be impossible. The presence of tonic inhibitory influences of SC on function of the ipsilateral LGB was demonstrated previously [11, 12]. More recently [1] the present writers showed that collicular influences spread not only to the ipsilateral, but also to the contralateral LGB. Moreover, in the second case tonic inhibitory influences of SC are much weaker than in the case of the ipsilateral LGB. As was pointed out above, this phenomenon is linked [8, 9] with the participation of SC in the organization of saccadic inhibition of LGB function. It is well known, however, that during activation of the ocular muscles induced by stimulation of SC, inhibition of function of SC itself is observed [5, 6]. Consequently, at this moment of time SC cannot have any significant influence on LGB function. However, during the few milliseconds before the saccade begins to develop, the so-called presaccadic discharge of the SC neurons is formed [7]. It is perhaps at this moment that SC exerts its influence on LGB function. Since the duration of the presaccadic discharge of SC neurons is quite short — not more than a few tens of milliseconds — it can be postulated that during this period SC is able to exert a rapid phasic influence on LGB function. Whereas this type of collicular influence has been demonstrated, albeit indirectly, for the LGB ipsilateral relative to the stimulated SC [11, 12], control of the function of the contralateral LGB has not been studied at all from this standpoint. Meanwhile some existing morphological [2] and electrophysiological [13] data suggest that influences of SC on function of the contralateral LGB of this type may exist. It was accordingly decided to study whether collicular influences on function of the contralateral LGB are exclusively tonic in character, as was described previously [1], or whether SC can also exert a rapid phasic influence on function of the contralateral LGB. The solution to this problem may shed additional light on the mechanism of the effect of saccadic suppression of LGB function, and, consequently, on function of the whole visual-oculomotor system.

EXPERIMENTAL METHOD

Experiments were carried out on 10 cats anesthetized with pentobarbital (35 mg/kg). Electrical stimulation of SC was carried out by application of a single square pulse, with a strength of 80-100 μ A and duration 0.1 msec. The results were averaged by the "Élektronika-100I" and AVE-256A (Hungary) computers. Changes in amplitude parameters of visual evoked potentials (EP) of LGB was carried out by the method of calculating the ratio of the amplitude of the response to a testing photic stimulus to the amplitude of the control response to a similar stimulus, expressed as a percentage. For short interstimulus intervals (from 0 to 5 msec), before the response to the conditioning collicular stimulus has been formed, the calculation was done by the method in [14], by the equation:

$$B = 1 - \frac{A_c}{A_1 + A_2} \cdot 100 \%,$$

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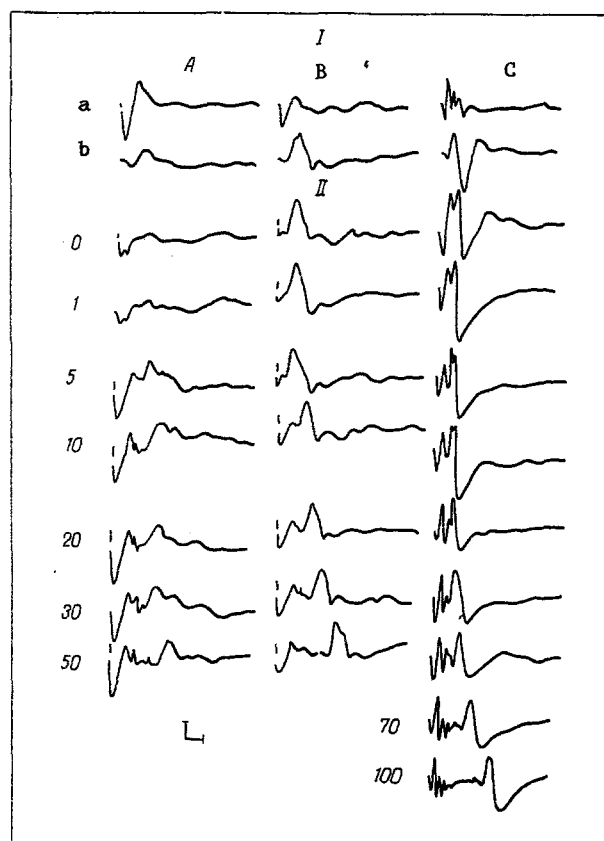


Fig. 1. Effect of stimulation of SC on formation of visual responses of contralateral LGB. I) Responses to single stimuli; a) colliculogeniculate response, b) responses to photic stimulus; II) responses of LGB to presentation of paired stimuli: conditioning – collicular, testing – photic. A) Responses recorded at surface of layer A', B) at level of middle part of layer A, C) at level of lower part of layer A. Numbers on left of traces indicate intervals between stimuli (in msec). Calibration: 50 μ V, 20 msec.

where A_c is the amplitude of the combined response for short intervals between stimuli, A_1 the amplitude of the control response to the conditioning stimulus, and A_2 the amplitude of the response to the testing stimulus. At the end of the experiments the location of the tips of the recording and stimulating electrodes was verified morphologically and the numerical data subjected to statistical analysis.

EXPERIMENTAL RESULTS

The experiments showed (Fig. 1a: I) that stimulation of the deep layers of SC by a single pulse of current led to the formation of a biphasic (positive-negative) colliculogeniculate response (CGR) in the superficial part of layer A of the LGB contralateral with respect to the stimulated SC. The latent period of this response was 3-4 msec. The duration of the positive component was 12 ± 9 msec and of the negative component 27 ± 9 msec. The amplitude of the positive component of CGR was $150 \pm 29 \mu$ V and of the negative component $100 \pm 17 \mu$ V.

The visual response recorded at this level consisted of a negative wave with an amplitude of $50 \pm 7 \mu$ V (Fig. 1A: I).

If the CBG preceded the visual EP of LGB, definite changes in the formation of the latter were observed (Fig. 1B; Fig. 2). These changes were expressed as follows. In the case of simultaneous presentation of collicular and photic stimuli or if the interval between them was 1 msec, no response was formed to the testing photic stimulus. With intervals of 5-10 msec, the formation of a response to the photic stimulus much reduced in amplitude (by $30 \pm 9\%$) was observed. A further increase in the intervals, up to 20 msec, led to virtually complete recovery of the amplitude of the response to the testing photic stimulus.

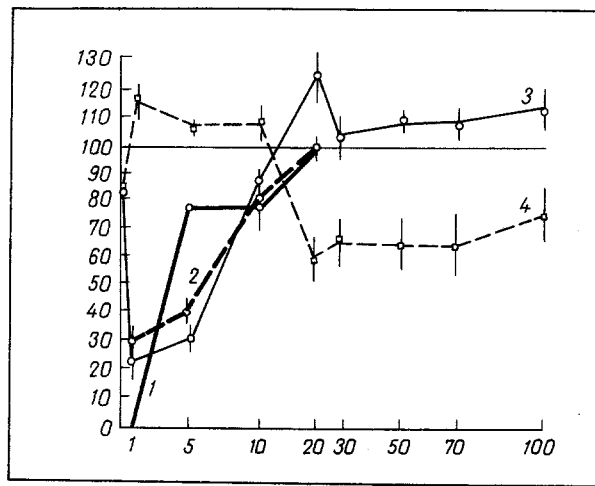


Fig. 2. Amplitude parameters of visual response of LGB as a function of intervals between conditioning collicular and testing photic stimuli. Ordinate, amplitude (in per cent of control); abscissa, intervals between stimuli (in msec). 1) Amplitude of visual EP of superficial part of layer A; 2) middle part of layer A; 3) negative component of response of deep part of layer A; 4) positive component of deep part of layer A.

Insertion of the recording electrode as far as the middle part of layer A of LGB led to a marked decrease in amplitude of CGR (by $40 \pm 15\%$) and to a considerable (almost 2.5-fold) increase in amplitude of the visual EP of LGB (Fig. 1B: I). Simultaneously with changes in formation of the responses of LGB, the intensity of the collicular influences weakened (Fig. 1B: II; Fig. 2).

Further insertion of the recording electrode as far as the lower part of layer A of LGB induced an even more marked change in the formation of both CGR and the visual EP of LGB. In this case, however, the changes were more qualitative than quantitative in character. For instance, the positive-negative complex of CGR recorded at this level of LGB was followed immediately by a series of fast negative waves, not recorded in the superficial parts of layer A (Fig. 1C: I). In the case of the visual EP recorded at this level of layer A, the appearance of a positive component not recorded in the superficial parts of layer A also was observed. It has been suggested [3] that the genesis of this component is linked with activity of LGB interneurons, located on the boundary between layers A and A₁ [15]. Since the fast negative waves of CGR and the positive wave of the visual EP of LGB are recorded at the same definite level of layer A, it can be tentatively suggested that the same, probably intrageniculate, interneurons take part in their generation.

Besides changes in the formation of evoked responses of LGB changes also took place in the character of collicular influences on its function (Fig. 1C: II; Fig. 2). For instance, in the case of simultaneous presentation of the conditioning collicular and testing photic stimuli, inhibition of formation of both negative and positive components was observed. With short intervals between stimuli — from 1 to 10 msec — there was a marked increase in the amplitude of the positive component and a marked decrease in the amplitude of the negative wave. A further increase in the interstimulus intervals gave the opposite effect: the amplitude of the negative component increased appreciably whereas formation of the positive wave was considerably inhibited.

The results are evidence that SC has not only a tonic inhibitory effect on function of LGB contralateral with respect to it, as has been described by the writers previously [1], but also a phasic effect. The character and intensity of this effect largely depend on the particular neurons of LGB to which they are addressed. For instance, neurons in the upper part of layer A, receiving mainly slowly conducting X-fibers from the retina [10], are subjected to a marked inhibitory influence of the contralateral SC. At the level of the lower part of layer A of LGB, however, where relay neurons innervated by fast-conducting V-retinal fibers and interneurons are located, the collicular phasic influences are varied in character. It was shown previously [8, 9] that stimulation of SC leads to transient (not more than 10-20 msec) excitation of interneurons, inhibitory for LGB and located in the optic zone of the reticular nucleus of the thalamus. Since during the same time intervals we observed inhibition of formation of visual EP in the superficial and middle parts of layer A of LGB, it can be postulated that reduction of their amplitude was the

result of activation of precisely these same interneurons. The inequality of the changes in the formation of the negative and positive components of the visual responses of the deep part of their A of LGB against the background of stimulation of the contralateral SC can evidently be explained by complex relations between SC and the interneurons of the reticular nucleus of the thalamus and, in turn, between them, the perigeniculate interneurons, and relay neurons and interneurons located actually within LGB [4, 8, 15, 16]. This investigation does not give an exhaustive answer to the question. It can only be postulated that two or more types of neurons, subjected to unequal influences from the contralateral SC, participate in generation of the visual EP of the deep part of layer A of LGB.

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