

INSTRUMENTAL OCULAR CONDITIONING IN ACUTE PRETRIGEMINAL CAT

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Soon after the description of the pretrigeminal cat in 1958 (4) it has been fairly well shown that the isolated cerebrum of this preparation works in many respects normally. In particular, orienting ocular reflexes can be evoked (13), and with use of electrical stimulation of the perifornical hypothalamic area as unconditioned stimulus, pupillary conditioned reflexes can be established in this preparation (1, 15).

Recently Shlaer and Myers (12) and Ikegami et al. (8) reported that instrumental conditioned reflexes can be established in the pretrigeminal cat. The vertical eye movement was used as an instrumental response (horizontal eye movements are absent in the pretrigeminal cat) and the electrical stimulation of the lateral hypothalamic area (10) as a reward. Each cat's eye movement of appropriate direction (upward or downward) and magnitude was rewarded.

In the present study an attempt was made to establish conditioned vertical eye movements evoked by *visual stimuli* in the pretrigeminal cat. A positive result of such experiment would increase the usefulness of this preparation in the investigations of higher nervous activity.

Five cats were used. Under ether anesthesia their brainstems were transected at the pretrigeminal level (13). The experiment started as the vertical ocular-following reflex (evoked by objects moved in front of the cat's eyes) reappeared, i. e. about 2 h after the transection. Since in all preparations this reflex habituated rapidly, they received a small dose (0.25–0.5 mg) of amphetamine (5). In cats 1 and 3 an additional small dose was given several hours later.

A previous study (6) showed that the average position for the pretrigeminal cat's eye at rest has an upward inclination of 13° . To make the visual axis approximately horizontal at rest, the Horsley-Clarke horizontal of the stereotaxic apparatus was tilted down by 13° . The left eye was covered with an occluder which did not disturb the eye movements, and the position of the right eye was recorded with a tensometric method and monitored on an oscilloscope (6). The spatial relationship between visual stimuli position and the eye position was established in each cat. Before recordings, the fixation reflex was evoked by a stimulus located at the averaged position of the pretrigeminal cat's eye at rest and the oscilloscope beam was positioned in the center of the screen.

As a conditioned stimulus a light slit ($1 \times 4^\circ$, 10 cd/m^2) presented for 2 s was used. The slit was displayed on a white tangent screen which was located 57 cm in front of the cat's eyes and illuminated with diffuse light (3 cd/m^2). The slit appeared 20° above or 20° below the average position of the fixation point for the pretrigeminal cat's eye at rest. We know (9, 14) that in the pretrigeminal cat such stimuli evoke fixation reflexes which habituate with repetition of the stimulus.

The unconditioned stimulus was an electrical stimulation (100 Hz, 1 ms pulse width, train duration about 1 s) of the lateral hypothalamic reward area (10). A bipolar electrode from 0.3 mm diameter Nichrome wire with tips 1 mm apart was used. The electrode was positioned according to coordinates suggested by Ikegami et al. (8) on the right side in cat 2 and on the left side in other cats. A stimulus intensity varied in different preparation from 40 to $200 \mu\text{A}$. This stimulus evoked a small dilatation of pupils and in cats 3, 4 and 5 a very small upward eye movement. Histological verification showed that in four cats the lateral hypothalamic area was stimulated (cat 1: A9.5, L4, V1.5; cat 3: A9.5, L4, V4; cat 4: A8, L4, V4; cat 5: A9, L4, V3), and in cat 2 the posterior hypothalamic area (A8, R1.5, V4).

An experiment consisted of 3-6 sessions. The intersession intervals lasted 30-60 min, but in cat 1 the two last sessions were held on the second morning after an interruption of 12 h. A session consisted of 30-150 trials. In cats 1, 2 and 3 the sessions were longer-lasting than in cats 4 and 5 and that facilitated the training. The intertrial intervals lasted about 1 min. The appropriate eye movements were immediately reinforced by the experimenter and thus the reinforcement coincided roughly with the second half of visual stimulus duration. Even relatively small but clear-cut eye movements were usually reinforced. The reflexes to four successive upper or lower slits were averaged with the Anops 10 analyser and recorded with an X-Y plotter.

The results are summarized in Table I. In the first stage of training

TABLE I

The effects of instrumental conditioned-reflex procedure in pretrigeminal cats

<u>Cat 1</u>					
Procedure ^a	Upper slit+ (28)	Upper slit- (61)	Upper slit+ (37)	Upper slit+ Lower slit- (28)	Lower slit+ (80)
Effect	full	partial	full	full	full
Procedure	Upper slit- Lower slit+ (153)	Upper slit+ (60)	Upper slit- (48)	Upper slit+ (104)	Upper slit- (20)
Effect	no	full	partial	partial	no
<u>Cat 2</u>					
Procedure	Upper slit+ (24)	Upper slit+ Lower slit- (48)	Lower slit+ (24)	Upper slit- Lower slit+ (92)	
Effect	full	full	full	no	
<u>Cat 3</u>					
Procedure	Upper slit+ (74)	Upper slit- (46)	Upper slit+ (76)	Upper slit- (48)	
Effect	full	full	full	no	
<u>Cat 4</u>					
Procedure	Upper slit+ (27)	Upper slit- (64)	Upper slit+ (63)	Cat 5 Upper slit+ (50)	Upper slit- (41)
Effect	full	partial	full	full	unclear

a, Stimuli and number of trials. Symbols: +, stimulus rewarded; -, stimulus not rewarded.

the upper slit was used as a positive conditioned stimulus. It evoked from the very beginning a clear-cut upward eye-movement which was reinforced by hypothalamic stimulation. Good reflex was maintained during this stage which lasted from 24 to 74 trials in different cats. Poor responses (which were not reinforced) appeared infrequently.

In four cats an attempt was made to extinguish the established reflex (Table I). To maintain the level of arousal during extinction procedure, the hypothalamus was stimulated in the middle of intervals between slit presentations. Full extinction of the reflex was obtained in cat 3 and partial extinction in cats 1 and 4. In cat 5 the effect was unclear. The extinction was followed by reconditioning procedure when the upward eye movement to the upper slit was again reinforced. In cat 3 during the first trials of this stage the reflex had to be evoked by a stronger visual stimulus (a moving slit). Reconditioning was easily obtained in all cases. The extinction procedure was repeated two times in cat 1 and one time in cat 3 (Table I), but it was successful only in cat 1 after

a night break (Fig. 1). In three cases the reflexes were increased at the beginning and then they diminished rapidly (Fig. 1).

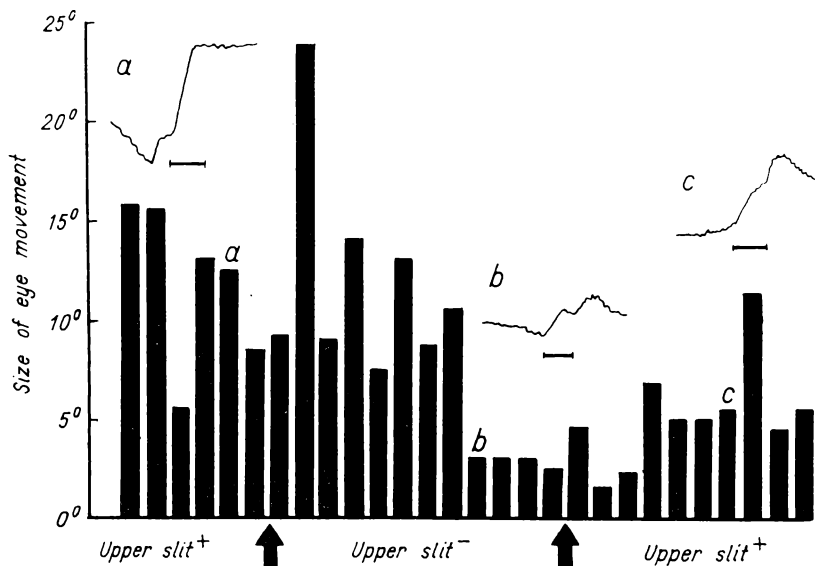


Fig. 1. Extinction and reconditioning of the eye movement to the upper slit. The beginning of the extinction and reconditioning procedures is indicated by an arrow. During extinction period (upper slit-) the lateral hypothalamus was stimulated in the intertrial intervals. Each bar represents mean amplitude of movements in four successive trials. Accordingly, zero value represents the position of the eye before stimulus presentation. During this session it was usually a few degrees above the averaged position of rest for pretrigeminal cats, representing 0° reference point for slit position. Three original Anops records are shown (visual stimulus indicated by horizontal lines), Cat 1, second morning.

In cats 1 and 2 an attempt was made to differentiate the upward and downward movements. The upper stimulus (reinforced) and the lower stimulus (nonreinforced) were usually presented alternatively. The differentiation was obtained in both cases (Fig. 2).

In these cats an attempt was made to establish a reversal of differentiated responses. In the first stage of reversal training the lower slit was reinforced, and clear response to this stimulus was established in both cats (Fig. 2). In the second stage, the lower slit (reinforced) and the upper slit (nonreinforced) were presented alternatively. In both cats the response to the upper slit was not extinguished.

It should be noted that the size of eye-movements (shown in Figures) depended not only on the position of the slit (+20° or -20°) and on the

conditioned-reflex training, but also on the position of the eye at the moment of stimulus presentation. This position depended on three factors: (i) In a cat the resting eye position differed by several degrees from the averaged position for pretrigeminal cats (6), which was the reference point (0° point) of stimulus position. (ii) In confirmation of previous data

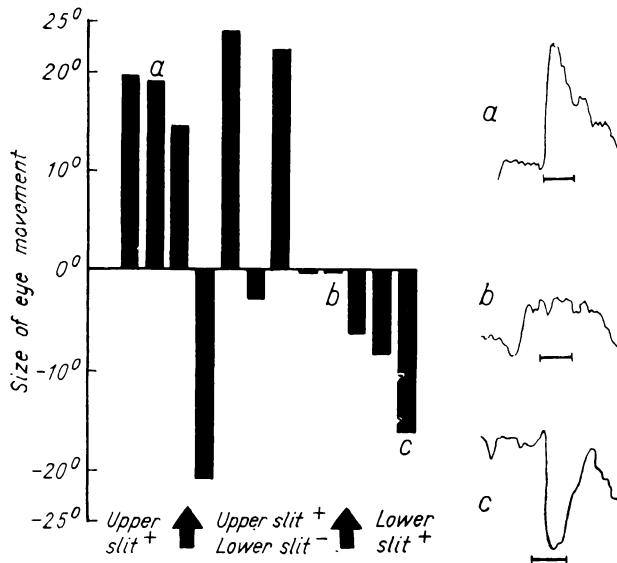


Fig. 2. Differentiation of eye movements to the upper (rewarded) and the lower (nonrewarded) slits. After obtaining the differentiation the positive response to the lower slit was established. The beginning of the differentiation (upper slit+, lower slit-) and reversal (lower slit+) procedures is indicated by an arrow. The movements to the lower slit are indicated below the horizontal axis. The two last bars during differentiation period represent zero values. During differentiation the upper and lower slits were presented alternatively, but because of technical reasons only the responses to one stimulus were recorded. Thus when four responses to the upper slit were recorded and averaged, four responses to the lower slit were abandoned, and vice versa. Cat 2. Other explanations as in Fig. 1.

(14), when only the upper or only the lower stimulus was presented many times in succession, the position of eyes during intertrial intervals tended to be higher or lower by a few degrees, respectively. (iii) Spontaneous eye movements occurred in all cats, caused presumably by electrical stimulation of the hypothalamus and amphetamine application.

The main methodological difficulty in the conditioned-reflex studies on the pretrigeminal cat is that the stimulation of hypothalamic areas arouses the cats and pseudoconditioning effects are possible. In the previous studies (1, 8, 12, 15) the authors made several control tests to indicate that true classical or instrumental conditioned ocular reflexes were

established in these preparations. Also in this paper the main effort was to prove that after conditioned-reflex training the true conditioned reflexes were present.

Another difficulty appears when acute preparations are required to master rather complex learning tasks. After several hours of training, when our best cats (cats 1 and 2) failed at reversal learning, the experimenters were also tired and avoided with difficulty errors in the correct rewarding of responses to stimuli with changed meaning.

Our results have confirmed previous report (8, 12) stating that instrumental conditioned reflexes can be established in the pretrigeminal cat. This result is important for three reasons: (i) It confirms earlier data (7) that proprioceptive input is not essential for elaboration of instrumental response. In the pretrigeminal cat the proprioceptive feedback from the extraocular muscles would be available only via oculomotor nerves, and we know (2, 3) that in cats such input is at best poor. (ii) Good functioning of the isolated cerebrum of the pretrigeminal cat is confirmed. (iii) The possibility of contact with an isolated cerebrum is demonstrated. The practical importance of such contact has been recently shown by Plum and Posner (11). Their patient with bilateral nasal pontine infarction had only the voluntary vertical eye movements preserved and with them he could indicate "yes" or "no".

On the other hand, in the light of the metodological difficulties mentioned above, we think that an acute pretrigeminal preparation with established ocular instrumental reflexes cannot be considered at the present state an easy model in neurophysiological investigations.

We thank Professor W. D. Glezer for collaboration and Mrs. J. Rokicka and Mr. J. Foga for technical assistance. This work was performed within the Inter-mozg collaboration and was supported by Project 10.4.1.01 the Polish Academy of Sciences.

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Accepted 30 September 1977

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