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TARGETING REFLEX: SOME FEATURES AND INHIBITION

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The reaction elicited by a neutral stimulus has been commonly called "orienting response" and many of its peculiarities have been analyzed (Pavlov 1951). Sokolov (1963) indicated that this response is non specific regarding quality and intensity of the stimulus and that its repetition provokes the extinction of the orienting response. Different components of the response have been pointed out, such as motor, vascular, cardiac, psychogalvanic and electroencephalographic (*see* Heisler 1958). Konorski (1967) has recently stated that the "orienting reaction" is complex, formed by the targeting reflex, autonomic responses and changes in alertness of the animal, mainly indicated by activation of the EEG. He adds that the targeting reflex is a reaction consisting in "adjusting the afferent system to the reception of the stimulus".

Lebedinskaia and Rosenthal (1936) have demonstrated that after full decortication, dogs are still able to present targeting reflexes. Thompson and Walker (1963) demonstrated more recently that inhibition of this response after removal of the auditory cortex of the cat is facilitated.

In spite of the fact that the literature offers many works regarding the orienting reaction and/or targeting reflex, data showing a quantitative picture of its inhibition by repetition of the stimulus in normals or in animals with cortical lesions are scarce.

The aim of the present work is to study the configuration of the targeting reflex, its temporal display and inhibition, and to observe the effect of some cortical lesions on its different components.

METHODS

A general description of the targeting reflex was done in different species, including humans, observed in different environments (houses, zoos, animal houses, laboratory, etc.). These observations tried to establish the activity of the different components of the reflex in the targeting process. This reflex can be advantageously observed using a dry short sound such as a crack produced by finger tip or tongue.

Sixteen cats, divided into two control groups and two operated groups, of four cats each, were regularly trained. Control groups were: Group IA, stimulated by a constant frequency sound (1000 cycle/sec) and Group IB, stimulated by a pattern of frequencies (from 1 to 100 cycle/sec). This pattern remained the same throughout the whole training period. The intensity of the sound was kept constantly at around 40 db over the human threshold.

The operated groups were: Group IIA, with a lesion involving the auditory area, and Group IIB, in which the anterior and posterior sigmoidean gyri were ablated. Ten days after the operation, training was initiated.

Observations were performed in a standard sound-proof chamber. Animals were habituated to the experimental environment 20 min daily for two days before onset of the training. The training period lasted ten days. The stimulus was presented 20 times daily with 1 min intertrial intervals. The loudspeaker was placed on the left side of the animal, diagonally, one and a half meters to the side and overhead. The animals were fed 2 hr before the session.

The following responses were statistically analysed (quantitative analysis):

Searching response, motor reaction involving the whole body, with or without locomotion tending to localize the stimulus.

Cephalic response, motor reaction of the head displaying the auditory receptor towards the sound.

Auricular response, motor reaction involving one or both ears, tending to better localize the sound.

Other cephalic responses, any movement of the head which does not help the animal to localize the source of the stimulus.

Negative behavioral response, no behavioral reaction elicited by the stimulus.

The decrement of the reponsiveness of the animals throughout the total training was described as intersession inhibition while intrasession inhibition was defined as the statistically significant decrease in the number of targeting reflexes in the second half of the session compared to the first one.

Statistical analysis of the data was performed through non parametric tests: Wilcoxon, Mann Whitney and analysis of variance for matched pairs.

After training, the operated animals were perfused in saline solution and formalin and the brain histologically processed to permit the reconstruction of the lesions.

RESULTS

I. General observation

The observation were mainly performed in cats but complemented in dogs, monkeys, apes and human infants, in different environmental conditions. The behavioral pattern of the targeting response to auditory stimuli is different, depending on the animal's capacity to move the external ear independently of the head. Cats and dogs can scan the environment by moving the pinna alone, while monkeys, apes and humans have to move the whole head. Another factor that plays a role in the pattern of the targeting reflex is the position of the stimulating source. If it falls in the animal's field of vision, only small head or eyeball movements, accompanied or not by auricle displacements, are observed. These movements tend to place the stimulating source in the focal field. If the source of the stimulus falls out of the visual field, primates move the head and eyeballs, while cats and dogs move the ears followed by cephalic and ocular movements, trying to target the source with the eyes. In the case of cats and dogs, movements are rapid, and it is difficult to observe the events in succession. Once the animal localizes the source of the stimulus, it might approach it, avoid it or remain indifferent.

If finger or tongue cracks are produced at the required intervals, a dissociation of the auricle and head movements can be observed; the display of events can be seen even better if the animal is asleep. In a sleeping animal (EEG synchronized or activated) the initial stimulus can be ineffective, but if repeated, pinna movements are aroused. Only continued stimulation evokes the above described reaction, awakening the animal.

II. Qualitative analysis

Adaptation period

Two adaptation sessions, twenty minutes each, were performed before training, during which animals showed an exploratory behavior consisting in sniffing and moving about. This lasted for 5 or 6 min after which animals remained inactive until the end of the observation. Rarely, liberation reflexes appeared at the beginning of the session. The most active group, in this period, was IIB.

Training period

During the ten sessions of training, the animal's behavior was observed before, during and after the presentation of the stimulus. In the first three or four sessions the animals showed an active behavior before the onset of the stimulus, consisting in exploratory movements, vocalization (miauling), scraching and cleaning. The frontal group, in this period, showed uncoordinated and unaimed activity. The onset of stimulation evoked not only reactions related to the targeting reflex, but also others which we grouped in the following way:

Accomodation responses consisted in slight movements provoked by the stimulus. These movements did not alter the animal posture, but they seemed to accomodate the body to a given position. This reaction could be accompanied by a targeting reflex.

Interception of behavior, sometimes the stimulus produced a transient interruption of the behavior. Once the stimulus ended, the animals continued their previous activity.

Initiation of behavior, in this case the animal was quiet and the stimulus induced a peculiar behavior that did not tend to target the stimulus. For example, to explore the cage, to clean and scratch itself. This behavior could continue or not after interruption of the stimulus. Mean values for group intersession showed that Group IIA presented 1.58 times (lowest) and Group IIB 2.67 (highest), which agrees with the highest activity presented by group IIB.

Postural changes, animals changed their position when they received the stimulus and very rarely in other circumstances. The postures more commonly adopted were: standing on all four legs, sitting up sphinx position, and curled up position.

Eyelid response, consisting in opening and closing the eyes during stimulus administration. This response could be accompanied by the targeting reflex.

Liberation reflex, occasionally provoked by stimulation. This reaction consisted in trying to escape from the cage, sometimes accompanied by miauling.

In general, the responses described above, appeared infrequently. For this reason, it was not possible to study them in numerical correlation with the other data analyzed.

The activity of the animals decreased through the sessions. Some of them kept quiet all the time (in a curled up position). In the last sessions, the animals of control groups were frankly sleep or drowsy.

III. Quantitative analysis

Control groups

Intersession processes

Searching response. This was a movement of the whole body including head and ears and tending to localize the origin of the stimulus. However, the number of these responses for each group in the ten sessions was very reduced. The mean number for the ten sessions was 0.40 for Group IA (lowest mean) and 2.78 for Group IB (highest mean). The searching response appeared only in the first quarter of the session.

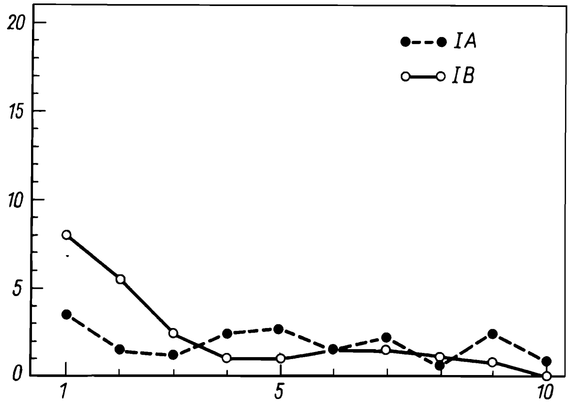

FIG. 1. Cephalic component of targeting reflex. IA, control group stimulated by a 1000 cycle/sec tone; IB, control group stimulated by a pattern of tones varying from 1 to 100 cycle/sec. In this and subsequent figures: abscissa, experimental sessions, ordinates, number of positive responses.

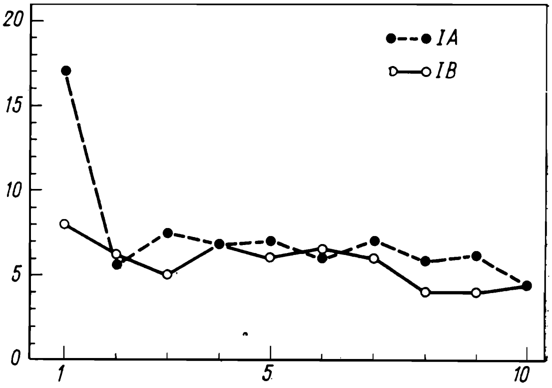

FIG. 2. Auricular component of targeting reflex. Same groups as in Fig. 1.

Cephalic components of the targeting reflex. In Fig. 1 an intersession decrement for the cephalic component of the targeting reflex can be observed in groups IA and IB. Comparison of both curves indicates that there are no statistically singnificant differences between IA and IB. The starting point is higher for IB than for IA. The intersession decrement through the training period is statistically significant for IB ($p < < 0.001$) though not for IA ($p < 0.1$–0.2).

Auricular component of the targeting reflex. The course of the auricular component of the targeting reflex can be observed in Fig. 2. Group IB shows a non significant tendency towards a decrease in the auricular component of the reflex ($p > 0.7$–0.5). Group IA shows the same phenomenon, a non significant decrement ($p > 0.2$–0.3), but in this case, the mean value of responses observed in the first session is clearly higher than that observed in the following sessions. Comparison of both groups does not indicate a significant difference.

Other cephalic responses to a targeted stimulus. Figure 3 shows the distribution of "other cephalic responses". A statistically significant difference between both groups is evident ($p < 0.002$). Group IA yields more responses than Group IB. Both groups show a rather stable amount of responses through the training period.

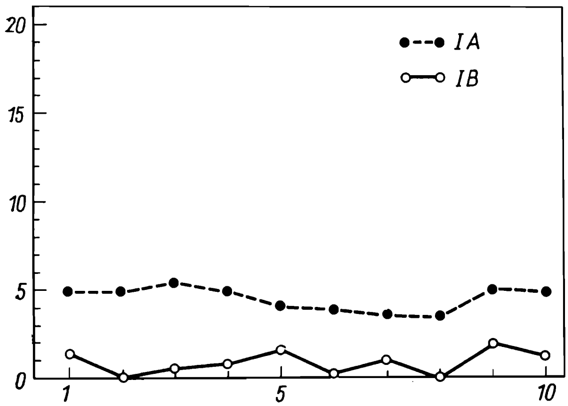

FIG. 3. Other cephalic responses. Same groups as in Fig. 1.

Negative behavioral response. Figure 4 shows the so called "negative behavioral response", that is to say, lack of any kind of response to the stimulus. In Group IA this type of behavior increases markedly, although it is still not statistically significant ($p < 0.2$–0.1), nor is it in Group IB ($p < 0.5$–0.3). Group IA yields fewer responses than IB and this difference is statistically significant ($p < 0.05$).

It is interesting to note that during training a clear modification of the intensity and complexity of the response described was observed. As training progressed the targeting reflex became poorer. At the beginning the animal made body movements including cephalic and auricular responses. Later, these body movements were supressed, a clear displacement of the head of 45° or 90° being observed and finally, slight head movements concomitant with the auricular component were noted. The same phenomena were observed in "other cephalic responses" which at first were very complex and later became stereotyped.

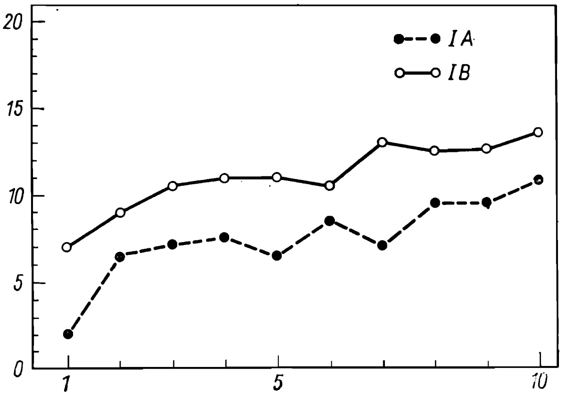

FIG. 4. Negative behavioral response. Same groups as in Fig. 1.

Intrasession processes

Group IA does not show statistical differences between the first and the second part of the session for the "cephalic component" of the targeting reflex, nor for "other cephalic responses" or "negative behavioral responses", while the "auricular component" of the targeting reflex shows a significant decrease through the ten sessions, as can be seen in Fig. 5 ($p < 0.005$).

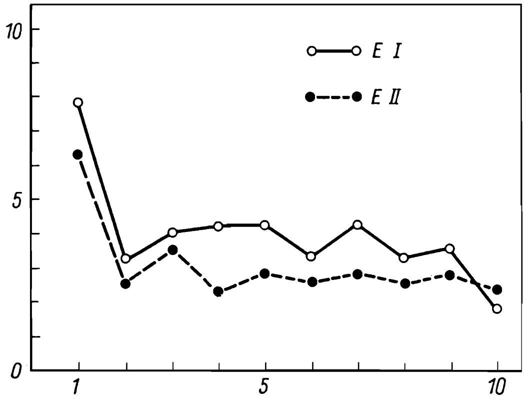

FIG. 5. Auricular component of targeting reflex: intrasession decrement. EI, first part of session; EII, second part of session.

Group IB (variable frequency stimulation) does not present intrasession differences for "auricular component" and "other cephalic component", but does show a significant difference for "cephalic component" ($p < 0.002$) and for negative behavioral responses ($p < 0.02$). The animals were more quiet in the second half of the session than in the first.

Groups with cortical lesions

In Fig. 6 typical lesions for Group IIA and Group IIB are shown. The rest of the animals presented comparable lesions. No attempt to study degeneration was made, since in these experimental conditions there was no difference in the behavior of operated animals, but rather, between the operated and normal groups.

Auditory Group. This group does not show intersession inhibition of responses in any of the computed responses (Fig. 7–9).

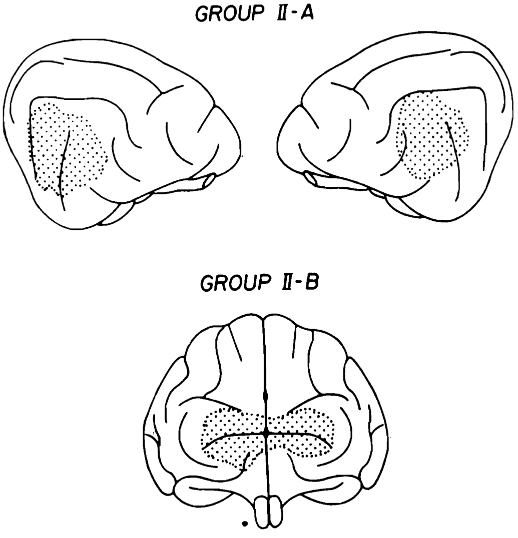

Fig. 6. Typical localization of the cortical lesions.

The analysis of intrasession inhibition was also negative, except for the "cephalic component" which tended to decrease significantly in the second part of each session ($p < 0.025$) (Fig. 10).

Frontal Group. This group does not show a significant tendency towards a decrease of the "cephalic component" of the targeting reflex (Fig. 7). The other curves such as "auricular component" (Fig. 8), "other

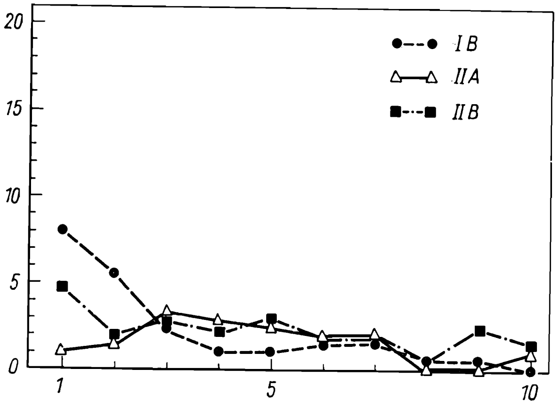

Fig. 7. Comparison of cephalic component of targeting reflex between control group (IB), auditory lesion group (IIA) and sensory motor group (IIB).

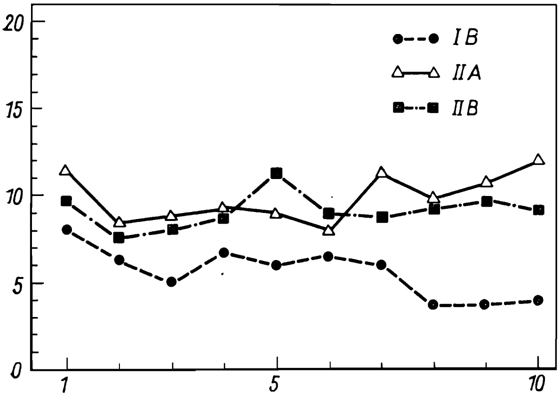

Fig. 8. Auricular component of targeting reflex. Same groups as in Fig. 7.

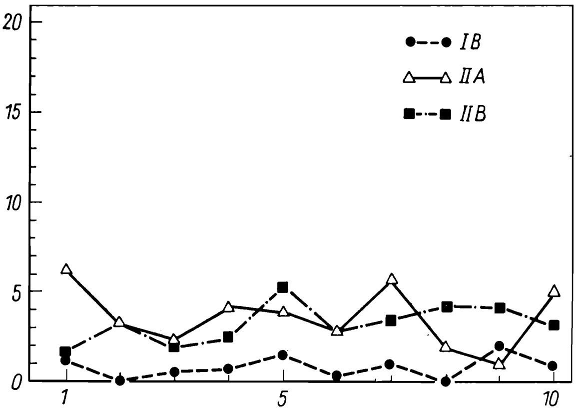

Fig. 9. Other cephalic responses. Same groups as in Fig. 7.

cephalic responses" (Fig. 9) and "negative behavioral responses" (Fig. 11), do not show any tendency to change throughout the 10 sessions.

As in the auditory group, the intrasession decrement of response is statistically significant only for the cephalic component ($p < 0.005$).

Comparison between control and operated groups

There were no differences between operated groups in the studied activities, but comparison between operated and control groups (Fig. 7–10) makes clear many differences. The control group (IB) showed fewer auricular components ($p < 0.002$), fewer "other cephalic responses" ($p <$ < 0.002) and more "negative behavioral responses" ($p < 0.002$) than operated ones. No significant differences in the "cephalic component" could be observed; however, at least in the first two sessions, the operated groups were less responsive than the controls.

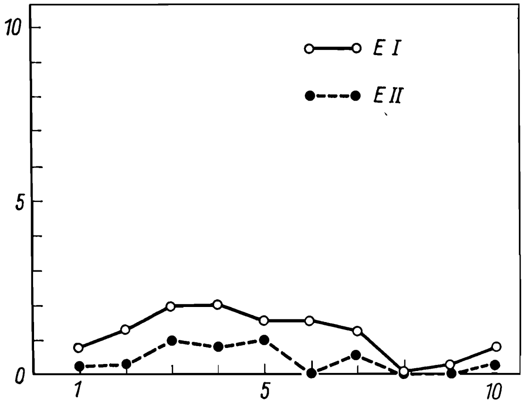

FIG. 10. Cephalic component of the targeting reflex: intrasession decrement. Same groups as in Fig. 7. EI, first part of session; EII, second part of session.

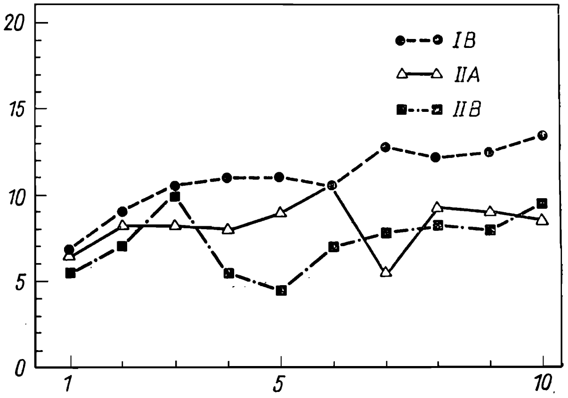

FIG. 11. Negative behavioral response. Same groups as in Fig. 7.

DISCUSSION

The terminology proposed by Konorski (1967) has been accepted because it permits a clear demarcation between the gnostic-perceptual component of the orienting reaction and others aspects, related rather to the afferent activity of the organism, such as modification of heart-rate, changes in muscular tension, changes in arterial pressure, etc. The targeting reflex is a reaction of the animal that permits the input of environmental information into the central nervous system (Razran 1961, Sokolov 1960, Konorski 1967) through more than one system of teleceptors, by coordinated changes of posture or/and changes in the display of the receptor's external organs.

Our results show that the auditory targeting reflex has at least three components: body, head-eyes and auricular movements are involved in the reflex. These components appeared dissociated during sleep and after cortical extirpation.

Cortical lesions do not supress the targeting reflex, although complexity and sophistication diminishes. Operated groups showed less "cephalic" component than did controls in the first sessions, but on the contrary, showed more "auricular" responses throughout the whole training period.

During sleep, animals reacted towards the acoustic stimuli with an auricular movement. The other components only appeared after full arousal.

The facts suggest that the auricular component is integrated mainly at a subcortical level. Body and head movements, on the contrary, require the functional integrity of cortex for full expression.

The increase of "other cephalic response" and the decrease of "behavioral negative responses" indicates that non adaptative patterns of behavior are released after decortication, or that the operation alters the capacity for adaptation.

Although inhibition of the targeting response is qualitatively clear, numerical results are not statistically conclusive. It is interesting to note that in the first sessions all groups presented a level of responses inferior to 50%, except for the auricular component in Group IA. This fact could be explained by postulating that inhibition is subsequent to the very first presentation of the stimulus, and that the way in which the problem was approached is far from physiologic because the experimental situation is too artificial. However, repetition affects the various components of the targeting reflex differently. It seems that the "cephalic component" is more susceptible to change through repetition of the stimulus than the "auricular component" is. The latter is less plastic and has fewer possibilities of being modified by experience. It is common knowledge that interruption of a permanent auditory stimulus is well perceived, giving origin to a targeting reflex. Furthemore, if a repeated stimulus does not evoke a targeting response but induces other motor responses (for instance "other cephalic movement", "interceptation", "palpebral movement", etc.), it means that information, sufficient to activate other efferent patterns, has entered the central nervous system, even if the targeting reflex is not fully elicited.

It is also comprehensible that at least some of the components of the targeting reflex do not experiment sufficient inhibition to reach a response of zero level. Organisms process information coming from outside even if they cannot react directly to it.

Inhibition of the targeting response was affected by cortical ablations. The curves of "cephalic" and "auricular" components were stable and no tendency towards a decrease was observed. There was no difference between operated groups, a fact which suggests that the cortex is not playing a specific role in the development of the inhibition of the targeting response. The loss of inhibitory capacity of the operated groups is also suggested by the fact that normal animals slept after training while those operated did not. The onset of sleep is probably related to an active inhibitory mechanism coming from the cortex. This latter showed inhibition later, as a consequence of a negative feed back from the subcortical structures. Operated animals do not fall asleep or become drowsy as normals do during the sessions of stimulation. The importance of this fact is obvious, as we are dealing with a cortical mechanism of active sleep regulation.

SUMMARY

The inhibition of the targeting reflex to a sound was studied as an ordinary learning process. Experiments were performed in four groups of cats: two control groups and two operated (one with a lesion in the auditory area and the other in the sensory cortex). The results showed that the targeting reflex has different components. Cephalic and auricular components were analyzed mainly. These components are clearly dissociated by repetition of the stimulus, by cortical operations affecting the auditory area, and by sleeping states. The meaning of some of these facts is discussed.

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