THE TARGETING REFLEX

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Insight into the exploratory and perceptual capacity of animals has evolved very quickly in our century. Pavlov (27) designated with the name of “chto eto takoe” reflex behavior that includes the reaction to a new stimulus and at the same time the tendency of the animal to explore it. He called the capacity of the animals to give up the response after a certain number of presentations of the stimulus, extinction of the reflex.

The works of Hernández-Peón and his colleagues (12, 15, 16) stimulated discussion of some integrative nervous phenomena provoked by a repetitive transient stimulus. Simultaneously, Sharpless and Jasper (30) published a study in which they showed that in a drowsy cat, the repetition of an arousing stimulus loses its ability to induce cortical activation. This was termed “habituation” and had a concrete meaning: a decrease of sensory evoked activity induced by a repetition of the stimulus which elicits it. The term “habituation” was later generalized to many behavioral and neural activities analogous to those observed for the evoked response. It has been applied, for instance, to the activity of a single cell (11), or to the inhibition of behavioral responses. Hernández-Peón et al. (13, 17) suggested that “habituation” underlies some behavioral traits such as lack of attention, inhibition of the orientation reaction, etc.

Konorski (18) in 1967 (p. 504–505), proposed a new approach to this problem. He designated as “targeting reflex” the motor reaction directed to allow the best perception of a stimulus by the animal, inducing the activation of the effectors related to determined peripheral receptors, or facilitating the intermediate structures related to a given perception.
He called the general somatic-autonomic reaction given by an animal when confronted with a new stimulus "orienting reflex", and, the reflex activated by the curiosity drive, consisting in a succession of targeting reflexes, "searching reflex".

The terminology proposed by Konorski makes a clear distinction between the gnostic-perceptual aspect of the problem, and the emotional viscero-muscular change concomitants. The targeting reflex is a perceptional reflex because information entering a channel is able to modify the receptive conditions of the same channel or of other efferent channels. The targeting reflex is a function which permits the nervous system to optimize the input of information to a given perceptual channel. The targeting reflex can be monosensorial or bisensorial. In the first case a given sensory input determines a modification of its receptor area, e.g., in the case of the ocular fixation reflex. In the second case, one sensory modality induces the modification of the receptor conditions of other afferent channels as in the case of the auditory-visual targeting reflex.

The targeting reflex becomes a concrete entity, a fact that helps in the research of its neural integration, delimiting the area of investigation and discussion.

*Evolution of the targeting reflex elicited by a repetitive audio-visual stimulating complex*

The work of Alvarado (2) and Alvarado and Santibáñe-H. (3) was devoted to observe the evolution of the effector pattern of the targeting reflex as long as the stimulating set is repeated. It is needless to say that this evolution depends on different factors, such as the properties of the stimulating complex, the anatomical structure of external receptors of the animal, the functional state of the central nervous system, and the common history of the animal and the stimulating set.

Schematically, three stages of development can easily be observed.

1. *Formation*. The formation of the auditory-visual targeting reflex varies from species to species, depending, among other factors, on the mobility of the external ear of the animal.

A good technique for observing this phase consists in stimulating the animal with a very short auditory stimulation and/or a moving source, especially when the animal is drowsy. In such a condition the first visible response is a displacement of the auricle towards the source of the sound. The observation can be made in a domestic dog, provided the dogs is able the move its ears! At the short lasting stimulation the animal moves its ears like a radar antenna, stopping at a definite position. As soon as the next sound comes, the head moves in direction of the sound source,
in such a way, that the animal visually focuses on the space corresponding to the source. If the rotation of the head does not enable the focusing of the sound-source, a change of the body posture takes place. This occurs when the source is placed behind the head towards the midline of the animal. Under more careful observation, it is possible to notice that in some animals a movement of the eyes precedes or is simultaneous with the movement of the head. If the interval between two auditory signals is too long, the animal keeps its ears directed towards the sound, but after a while they return to the resting position. When the next signal comes, the animal again responds with its ears. This phase can be considered as finished as soon as the source is visually targeted.

2. **Consolidation.** As long as the stimulation is repeated, the targeting reflex becomes more and more precise. Unspecific movements are suppressed. The reaction is fluid and sure. The latency reaches its limit. This period can be considered as the optimal stage. The consolidation stage is particularly clear when the auditory stimulation is a conditioned signal. It is common knowledge that when a cat or a dog have acquired a food conditioned reflex, the targeting reflex triggered by the conditioned stimulus is extremely short. The animal tends mainly to focus the site of the unconditioned stimulus.

3. **Inhibition.** The inhibition of the reflex has two types of manifestation: the decrease of the response frequency and the modification of the reflex pattern.

Alvarado (2) studied the inhibition of the targeting reflex systemati-

Fig. 1. Development of the inhibition of cephalic (circles) and auricular (squares) components of the audio-visual targeting reflex in cats (N = 10). Twenty presentations of the stimulus in each session. Observe the rapid inhibition of the cephalic component of the targeting response.
cally. Groups of 10 animals were stimulated 20 times daily during 10 sessions with a tone emitted by a loudspeaker. In the first session the animals showed around a 40% of positive targeting responses, including body, oculo-cephalic and auricular components. In the third session, there were 10% of oculo-cephalic plus a 25% of pure auricular components; the body component was not present. In the tenth session, only the auricular component was present 20% of the times (Fig. 1).

Recently, I. Santibáñez and T. Moreno (personal communication) observed that the EOG indicating change of activity of the eye muscles was present 60% of the time while the auricular movements were present 25% of the time.

**Afferent neural blocking hypothesis**

The neurophysiological analysis of the targeting response began with the study of its inhibitory stage. In fact, the works of Hernández-Peón dealt with the “habituation” of the evoked potentials. This author interpreted the diminution of the size of the sensory evoked potential as a sign of lack of attention of the animal to the repeated stimulation. Hernández-Peón (12) put forward the hypothesis known as “afferent neural blocking”; he postulated that the mesencephalic reticular formation activated by repetitive stimulation should produce a block of the information input in the specific pathway, mainly in the central specific relay, as the cochlear nucleus, the lateral geniculate body, etc. This author based his hypothesis on two main facts: (i) If a cat with electrodes implanted chronically in some points of the specific channel — submitted to a repetitive stimulus and fully habituated — received an anesthetic dose of sodium pentobarbital, the animal fell asleep and the evoked potentials reappeared. (ii) If a fully habituated cat was submitted to an extensive coagulation of the mesencephalic reticular formation, the evoked potentials recovered their original size.

Together with Hernández-Peón, Alcocer-Cuaron and Lavin (14), we published a paper on the “habituation” of the evoked activity of the olfactory bulb by a repetitive olfactory stimulation. Hernández-Peón’s work suggested some ideas that did not always agree with his hypothesis:

1. In the normal cat, the decrease in amplitude of the evoked potential was facilitated by sleep.
2. The functional state induced by sodium pentobarbital was not produced by a selective blocking of the reticular formation, but by a diffuse action on the brain.
3. The extensive lesion of the mesencephalic reticular formation induced a state of “coma” in the animals.
4. It was not possible to explain the inhibition of the orienting reflex by the amplitude decrease of the sensory potentials, because the number of repetitions of the stimulus needed to produce the first phenomenon belongs to the order of the tens, while the number necessary to produce the second, belongs to the order of the hundreds.

Thus, in normal chronically implanted cats and in acute preparations "cerveau isolé" and "midpontine pretrigeminal" cats (5, 32), repetitive stimulation gave the following general results (23, 24).

1. Normal animals as well as those with isolated brains habituated with a synchronized EEG (Fig. 2).

Fig. 2. "Pretrigeminal preparation". EEG in each letter (A–B–C) from top to bottom: left occipital, right occipital, left frontal and right frontal. Visual potentials (A'–B'–C') evoked at the same time that the EEG (A–B–C) were recorded from primary visual area (upper), and from lateral geniculate body (lower). A–A': EEG synchronized and evoked potentials inhibited after 12 h of visual stimulation with a flash (1 cycle/s). B–B': Arousing effect on EEG and recovery of the original amplitude of the evoked potentials by intrareticular activating stimulation. C–C': Return to situation A–A' after new repetitive stimulation with flashes. Observe that intrareticular stimulation induces "dishabituation".
2. The classic "cerveau isolé" had to be stimulated for 30 min in order to obtain a clearcut reduction of the amplitude of the evoked potentials, while the "pretrigeminal" cat with the same pattern of stimulation needed around 12 h of stimulation in order to reach the same level of habituation.

Fig. 3. “Cerveau isolé” preparation. Photic repetitive stimulation. Evoked potentials recorded from lateral geniculate body. Continuous record to be read from bottom to top. First column (left): Visual evoked potentials at the beginning of the stimulation. Second column: Inhibition of the evoked potentials by stimulus repetition. Third column: Effect of activating intrareticular stimulation: the evoked potentials recover their previous amplitude. Fourth column: Injection of Nembutal (1-2 mg/kg) does not alter the blocking of the potentials. Fifth column: the reticular formation is blocked by Nembutal, because a new intrareticular stimulation is inefficient in inducing the amplitude recovering. Observe that the specific blocking of the reticular formation does not induce the reinstatement of the evoked potentials to the original size.
3. Intrareticular stimulation in chronic as well as in pretrigeminal and "cerveau isolé" cats did not induce a further habituation, on the contrary, it induced "dishabituation" (Fig. 2).

4. The injection of small doses of sodium pentobarbital 1–2 mg/kg for the "cerveau isolé" was enough to inactivate the reticular formation, while its direct stimulation did not bring about dishabituation (Fig. 3).

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**Fig. 4.** "Cerveau isolé" preparation. Photic repetitive stimulation. Evoked potentials recorded from primary visual area (upper trace) lateral geniculate body (lower trace). Continuous record to be read from bottom to top. First column (left): Evoked potentials inhibited by flash repetition. Second column: Injection of a small dose of Nembutal (1–2 mg/kg). Third column (at the point): intrareticular stimulation, inefficient in inducing a disinhibition of the evoked potentials. Fourth column (at the points): The dose of Nembutal is increased to 25 mg/kg, inducing by itself an increase of the amplitude of the evoked potential.
5. The administration of a larger dose of sodium pentobarbital determined, per se, the end of the “habituation” (Fig. 4).

6. The decrease of amplitude of the evoked potentials was observed first in the cerebral cortex and then in the lateral geniculate body.

These findings suggested the following conclusion: the decrease in amplitude of the evoked potential induced by a visual repetitive stimulus is concomitant with a functional inactivation of the reticular formation, and is facilitated by cortical inhibition. The diminution in amplitude of the evoked potentials was first observed in the cortex and not in the lateral geniculate body.

Affanni et al. (1) demonstrated that the amplitude reduction of the visual evoked potential in the visual pathway could be explained as a consequence of pupilar constriction, and Dumont et al. (7) showed that the diminution of amplitude of auditory evoked potentials was produced by the modification of the tonus of the medial ear muscles. These facts suggest that the phenomenon observed by Hernández-Peón could be caused by a modification of the accessory organs of receptors.

However, Meulders (25) affirmed that it is necessary to accept another point of view in order to understand the decrease in size of the evoked potentials by repetition of visual stimuli. In the “cerveau isolé” preparation, this author has demonstrated the following:

1. The amplitude of the evoked potentials does not show changes when eserine is instilled into the eyes of the preparation.

2. The decrease in amplitude of the evoked potentials takes place first in the associative areas, and then in the primary areas of the cortex. The stimulation is the same for preparations with or without eserine.

These facts indicated that in one way or another, a central process is also playing a role in this decrease in amplitude of the visual evoked potential, when a flash is repeated.

With Trouche and Fessard (28) we decided to study the effect of stimulus repetition on the central nervous system, excluding the peripheral analyzer. Thus, the radial nerve was directly stimulated. Electric square pulses (0.2–0.3 V, 0.5 ms) were applied through chronically implanted electrodes under the skin of the fore paw. The responses from primary somatic area, SI, and the ventroposterolateral, VPL, nucleus of the thalamus were recorded. A divergent modification of the amplitude of the evoked potentials tended to increase with the stimulus repetition, while the thalamic potentials tended to diminish (Fig. 5). It is well known that a repetitive stimulation given at a slow rate induces a synchronization of the cortical activity.

Cortical synchronization is always accompanied by a certain release of the muscular tone. Relaxation also reaches the muscles involved in the
control of external receptors such as ears and eyes. Cortical synchronization and muscular tonus diminution are correlated with the functional depression of the reticular formation. For this reason it is possible to postulate that both central and peripheral processes are involved in the modification of the amplitude of the evoked potentials.

![Figure 5](image)

Fig. 5. Primary somatic area, SI, ventro-postero-lateralis nucleus of the thalamus, VPL, and electrocorticogram, ECoG. Chronic cat. Each record is the mean of 50 evoked potentials. The contralateral radial nerve was stimulated with electric pulses: 0.8 V, 0.5 ms duration, and 1 cycle/s. After 5 h of stimulation, an increase of the amplitude of the evoked potentials was observed in the cortex, and a decrease in the thalamus.

The analysis of the efferent area

The role of the reticular formation as well as the ideas proposed by Hernández-Peón to explain the decrease in size of the evoked potentials do not seem to be corroborated by the facts. The decrease in size of the evoked potentials cannot be considered as the neurophysiological substrate of the inhibition of the targeting reflex because the inhibition of the reflex takes place long before the size of the evoked potentials is modified. Probably this diminution is in itself a consequence of a modification of the attentional process, but by no means, its cause.

There has been no adequate control of the correlation between targeting behavior and the neurophysiological processes leading to the diminution of the size of the evoked potential, and the most important is, that in our opinion, neither the reflex nor its neural integration, were well known. Thus it was difficult to find a good approach to the problem.

For these reasons we devoted part of our experimental work to study the targeting reflex with an efferent approach, i.e., observing the effect of different experimental manifestations on the “effection” of the reflex.
We were interested in knowing whether modulation of the mesencephalic reticular activity has an influence on the targeting reflex. To answer this question the following experimental series were performed (9). Three groups of 10 cats each, were stimulated 20 times with a 1,000 cycle/s tone lasting 30 ms during 10 daily sessions, in order to observe the evolution of the auditory-visual targeting. The control group was stimulated 3 h after “ad libitum” food ingestion. A second group with implanted electrodes into the reticular formation received a permanent electric discharge throughout the sessions (300 cycle/s, 0.5 ms duration, 60–80 μA) to keep the reticular formation activated. The third group was alternately satiated in one session and food-deprived —48 h— in the following. During the 10 sessions the group with intrareticular electrical activation did not show any tendency to inhibition, and gave around 60–80% targeting responses. The deprived-satiated group showed a tendency towards inhibition, but always in the session corresponding to the 48 h of food deprivation, the animals responded 20–25% more than in the previous satiated sessions. The control group showed the classical inhibition curve described elsewhere (Fig. 6).

**Fig. 6.** Cephalic component of the targeting reflex in cats. Mesencephalic reticular formation activated (squares) with 300 cycle/s, 0.8 V and 0.5 ms duration. 48 h of food deprivation (full circles with interrupted line) and fully satiated (empty circles with interrupted line). Control group, empty circles and continuous line.
A second experiment was performed in order to observe if the effect of different types of electric stimulation into the reticular formation had different effects on the targeting reflex (2). In fact, following the same schedule of stimulation, to induce the targeting reflex, three groups of animals were studied: one with an activating intrareticular stimulation, one with a depressing intrareticular stimulation, and one as control. The group with the activating stimulation gave results consistent with those of the deprived group of the previous experiment. The group with depressing stimulation responded less than the control group in the first three sessions. The effect of the reticular stimulation may be seen in Fig. 7.

Fig. 7. Cephalic component of targeting reflex in cats. (10 cats each group.) Mesencephalic reticular activation (empty circles and line interrupted by two points), 300 cycle/s, 0.6 V and 0.5 ms. Mesencephalic reticular formation depressed (empty circles and line interrupted by an x), 12 cycle/s, 0.8 V and 0.5 ms. Control group (filled circles and continuous line).

The effect of the extirpation of the somato-motor and auditory cortex was studied by Alvarado (2). Both lesions produced a similar effect on the targeting reflex. The evolution of the cephalic component was very similar to the control, except that in the first sessions the operated animals gave very few responses; on the contrary, the auricular component was facilitated as compared to the control.

The next step was to analyze what happens in the facial nucleus when an auditory-visual targeting reflex is taking place, and more specifically, how the nucleus responds when an acoustic stimulus is given to a cat. We concentrated our observations on the part of the nucleus that controls the external ear muscles (29). It has been found that different exteroceptive stimuli are able to activate this nucleus.
The analysis of single cell activity has shown that the cells can either respond specifically to different sensory modalities — visual, tactile, acoustic, and proprioceptive stimulation — or that one cell can respond to different modalities. The spontaneous discharges of some cells can be inhibited and then activated. There exist very complex interactions of ipsilateral and contralateral information, induced by the same and/or by different sensory modalities on a single cell.

The activity coming from the telencephalon can modify the sensory activity recorded in the facial nucleus (29). The auditory evoked potentials show two events: one of short latency, and the other of long latency. Bilateral lesions of the somato-motor cortex determined a drastic reduction of the long latency component (Fig. 8). A more dramatic effect was observed when a transection at a precollicular level was performed in the encephalic trunk of the animals (Fig. 9).

Espinoza (8) tried to establish correlations among the following four

![Image](image_url)

Fig. 8. Effect of lesions of the sigmoid gyrus on the auditory evoked potentials in the facial nucleus. Upper trace, facial nucleus; lower trace, auditory cortex ectosylvian gyrus. A, before operation; B, 8 days after operation; C, 20 days after operation. Note the alteration of the slow component of the facial nucleus auditory evoked potential.
variables: behavioral states (awake-asleep), electroencephalogram (synchronized-desynchronized), auditory evoked potentials (presence-absence), and auditory-visual targeting reflex (presence-absence). The correlations indicated that when the animal is asleep with a desynchronized EEG, there exists a minimal probability of observing a targeting response and an auditory potential in the facial nucleus. On the contrary, when the animals are awake, the EEG desynchronized, the probability for observing a targeting reflex and an auditory potential in the facial nucleus is maximal.

![Brainstem transection diagram](image)

Fig. 9. Effect of brain-stem transection at the pre-collicular level on the acoustically evoked activity of the facial nucleus. Series of pictures, one each minute (bottom-top). No effect on the short latency component, but drastic suppression of the long latency evoked component, may be seen. Repetition of the stimulation tends to develop a sketch of it. The interruption of the stimulation for 10 min caused its disappearance. Acute preparation.

However, there is not a high correlation between the existence of an auditory potential in the facial nucleus and the presence of an auricular targeting reflex. In many instances there exist auditory evoked potentials in the facial nucleus, but no auricular targeting reflex. In such cases other facial movements can be observed.

The succession of different movements in the cat's reflex, especially
that the reflex always starts with the auricular component, and that the auricular component is resistant to inhibition, encouraged us to consider the possibility of manipulating this component.

In collaboration with R. Aneiro-Riba and T. Moreno (unpublished data), some experiments were performed in order to understand the importance of ear muscle feedback on the auditory-visual targeting reflex. Thus, different groups of cats were trained for an auditory-visual targeting instrumental conditioning. In order to obtain food, the animals had to localize visually the loudspeaker from which they received a sound.

(Fig. 10). When a criterion was reached — three sessions with 80% correct responses — the muscles controlling the ear movements were excised. The main effect of the operation was a drastic reduction of the positive responses. Figure 11 shows the results in four animals submitted to ear muscle resection. The postoperative training period for each animal was as long as the preoperative one.

Recently, I. Santibáñez and T. Moreno (personal communication) performed the following experiments in order to visualize the importance of the ear muscle feedback and the sequence of events in the acoustic-visual targeting reflex. Eight cats were placed in the cage shown above for a period of 4.5 h, in order to accustom them to the experimental conditions. Four cats were then submitted to a denervation of the ear muscles. All the animals were implanted chronically with electrodes that allowed recording of the EOG, and the EMG of the muscles controlling the movements of the head and of the ear. In the cage the animals were stimulated with two different tone frequencies 100 and 1,000 cycles/s, that came at random from different loudspeakers, in order to retard the inhibition.
of the targeting reflex. All the animals received the same number of stimulus presentations.

The control group gave 62% ocular movements, 25% auricular movements and 11% cephalic movements. As a mean, the animals responded from 60% to 100% of the times they were stimulated. The denervated group showed some ocular, auricular and cephalic movements, 10% of the times they were stimulated.

**Targeting reflex, an intersegmentary reflex**

A schematic reconstruction of an audio-visual targeting reflex in the cat can give the following efferent picture: on hearing the sound, the animal scans with its external ear until it is able to localize the correct direction of the stimulus source. Simultaneously, or at the end of the movement of the ears, the eyes, or the eyes and the head move toward the source. If the fixation reflex is not possible, because the image does not fall within the visual field, the body moves in such a way that the image of the sound source falls onto the macula. In reality, the targeting reflex has a clear variability. Depending on the experience with a stimulating complex, scanning time of the ears may vary, oculo-cephalic body
movements may be more or less exploratory, while the sequence and type of movements may also change. For instance, eye movements can appear simultaneously with the ear movements when the animal has had a certain experience with a concrete targeting process, or may be retarded when the animal is less experienced. However, in spite of the variability, one thing is clear, the targeting reflex is an integration of different intersegmentary reflexes, a complex postural reflex of the type described by Magnus (21, 22). It is response of the organism which involves, totally or partially, the posture in relation to a particular spatial localization of a concrete source of auditory stimulation.

It should be remembered that the head components of the targeting reflex directly involve the muscles of the limbs, at least in a change of tonus of both sides. This fact is clear in decerebellated cats that practically fall down when they perform a rapid targeting reflex.

**Targeting reflex as a diachronic process**

Before the appearance of jet planes in the skies, many people had developed the ability to localize an airplane with good precision. We were used to hearing the sound of the engines and to perform an angular movement of the head with a certain speed. Once the plane was localized we could follow it with a slow displacement of the head. The first time I heard the rumor of a jet I performed these same movements, and to my astonishment, I was not able to localize the plane. Even a wider visual exploration of the sky was unsuccessful. Once I learned to localize jets, I observed that some variation had been incorporated into my targeting reflex: the angular movement of the head had to be much greater and executed much more rapidly than before. To follow the plane, the head had to be rapidly displaced, and body movements incorporated. This example shows how a given targeting reflex is affected by the full experience of the animal with a given class of stimulation. In relation to the audio-visual experience itself, three different time periods can be taken into consideration: (i) The first time in its life the animal reacts with a targeting reflex; (ii) The first time the animal reacts to a given stimulating model, and (iii) when other targeting reflexes are connected with experienced stimuli.

As a matter of fact, the audio-visual targeting situation is really new and not necessarily innate, the first time that it is performed. The following times, even if the triggering stimulus is unknown, the reaction belongs to a particular learning set, and as a consequence, is part of the past experience of the animal. Thus, a concrete stimulus, even though unknown for the animal, is at the same time new and old. It is new because the animal has not had the concrete experience of the stimulus, and
old, because it is part of a given learning set which allows a certain transfer of behavior.

It is a well known fact that in infant animals, including man, the audio-visual targeting reflex is concomitant with a complex emotional reaction in which curiosity and fear are mixed. Sometimes, this reaction is observed even in adult animals. When the animal becomes familiar with the external world, the emotional activity decays, the perceptual behavior remains, and as long as the stimulating model is repeated, it becomes more and more precise and rapid and then decays.

In short, the targeting activity of an animal is a process which flows through its whole life and in each concrete manifestation, its whole experience involved. Thus memory functions of the central nervous system are always present in each targeting reflex of an animal.

The targeted stimulating models

The patterns able to elicit an audio-visual targeting reflex in nature, are endless. As a matter of fact, each pattern can be considered new and old. A given stimulating model is new, if the brain differentiates information; it is old when the brain integrates it, but is simultaneously old and new when the brain performs both processes. The brain can work in an analytic and in a synthetic way, as Pavlov (27) has pointed out. This synthetic-integrative capacity is manifested as a generalization, a learning set, or a unitary perception, and also plays a role in the integration of the targeting process.

To establish the novelty of a stimulating model able to trigger a targeting reflex is extremely difficult, and would require a strict ecological control of the experimental material. The problem is not very important, at least at the present stage of research. What really must be considered is the modification of the stimulating pattern through the different interactions with feedback information produced by the development of the response itself. In fact, feedback coming from ear muscles, integrates a new stimulating model and probably other feedbacks may act in the same way. This special interaction between exteroceptive and interoceptive stimuli makes possible the genesis of a special kind of conditioned reflex. One can postulate, that sound acquires some of the properties of the feedback muscular signals, as in any other classical conditioning, and that this “sound-proprioceptive feedback conditioning” may be responsible for the gradual amelioration of the parameters of new targeting reflexes. This hypothesis can be extended, and considered a general integrative action on the neuroendocrine system and the physiological basis of the increase of response efficiency, in all repetitive motor performances triggered by an exteroceptive stimulus.
Another fact that needs to be stressed is that the variability in the stimulating model also induces a variability in the neural integration of the targeting reflex. It is sufficient to consider two different stimulating models in order to realize its importance. A stimulating model composed of a long lasting sound and a fixed source, and another composed of a short lasting repetitive sound and a moving source, require different neural integrations in order to be targeted. In the first case, the spatial relationship “animal-source” will be constant, while in the second, it will be variable. This difference makes the existence of variation in the integrative processes underlying different concrete targeting reflexes comprehensible.

Programmed and unprogrammed movements

A person concentrated on conceptual work can respond with a “startle” reaction if stimulated by a sudden auditory stimulus, even if the intensity of the sound is not great. In fact, the person may jump in his seat, and then try to investigate what has happened. Similar reactions can be observed when a drowsy cat or dog are stimulated by a sound. Concentration, distraction, or sleep, are functional states that do not allow the neuroendocrine system to elaborate a clear auditory visual targeting reflex when confronted with an acoustic stimulus. In neurophysiological laboratories it is a common experience that when working with chloralose, a not well narcotized cat will jump when stimulated with an exteroceptive stimulus. At the behavioral level, the generalized contraction of the muscles, even antagonists, produces a “spring” reaction. Ascher (4) showed that under chloralose different motor nuclei discharge at the same time, when the animals are stimulated exteroceptively. The movements seem to be “unstructured” and without an adaptive finality.

There are other movements that are sequentially integrated, fluid in their development, with a clear adaptive finality. These movements are usually the product of a learning process. Recent observations performed in human beings (6, 10, 19, 31), as well as in animals (20), suggest that voluntary movements in man, or conditioned movements in a cat, are preceded by a particular slow potential of the somatic-motor cortex. These potentials are larger in the hemisphere contralateral to the movement; they start 850-1000 ms before myographic activation, indicating onset of the movement. The larger the potential, the greater the intention of the subject to make a movement, and the bigger the amplitude of the movement. These potential may be interpreted as an electrophysiological expression of the planning of the movement to come, or of the decision to perform a given planned movement. In any case, these potentials may be related to the programming of the movements and the decision to perform them.
It is possible to believe that the effector component of the targeting reflex belongs to this type of movement. The facts found in our laboratory consisting in the alteration of the inhibitory process of the targeting reflex by decortication (2, 3), the absence of targeting reflex when the slow component of the auditory evoked potentials in the facial nucleus is absent, and the abolition of this component by frontal decortication (8, 29), permit the assumption that targeting movements belong to this type.

We may imagine the targeting movement in the following way: The auditory component of the stimulation will produce an activation of the "motor nuclei" eventually involved in the targeting reflex. Only the neurons controlling the auricular muscles discharge. The rest of the "motor nuclei" eventually involved in the targeting reflex. Only the ready to respond, as Mettler (26), pointed out. When the movement is "decided" in the upper structures, these neurons discharge in a fixed order, programmed in correlation with the feed back coming from the auricular muscles.

**Conclusions**

The auditory-visual targeting reflex is an intersegmentary reflex. In its most simple expression it is a movement of the external ears, while in its more complex form, it is a complicated change of posture involving the whole body. The reflex can be inhibited by a repetition of the effective stimulating pattern. The more complex patterns of the motor responses are more easily affected by the inhibitory process, while the more simple ones do not reach complete inhibition. The auricular component of the targeting reflex is only partially inhibited by the repetition of the stimulus.

The auditory-visual targeting reflex is a diachronic process, that is to say, a process in which each concrete stimulating model induces an activity of the neuroendocrine system which differentiates this particular information from the others, and, at the same time integrates this information with the information stored in the memory compartment of the brain. The response of the system is a consequence of this dialectic unitary process.

The level of general excitability of the central nervous system modulates the ability of the animal to target the audiovisual complex. The increase of this level induces a facilitation of the response, while its depression has a contrary effect. This reflex is an intersegmentary one, in which the effector feed back plays an important role.

The neural integration of the targeting is complex. We do not know enough about it. However, in this reaction there are neural functions,
such as, information storing, decision and planning of effector response, sound lateralization, visual localization, and others.

Figure 12 shows a very schematic block model of the possible functions involved in the targeting process. For the purpose of simplification

Fig. 12. Block Model. Integration of an audio-visual targeting reflex. Peripheral Analyzer Unit (PAU): Receptor surface of the Neuroendocrine System. Specific Central Analyzer Unit (SCAU): Different sensory channels from the sensitive ganglion to the sensory cortex. Kinodynamic Unit (KdU): All the system involved in the tonic or phasic regulation of the basal activity of the specific structures, i.e., reticular formation. Mnemic Unit (MnU): Neural function, related to the capacity of the nervous system to accumulate and recognize information. Kinetic Model Generator Unit (KMGU): Neural function that allows the neuroendocrine system to dispose and to generate different movement programs. Kinopraxic Unit (Kp U): Neural function to produce movements selected by the KMGU, anatomically represented by the motor nuclei. Model Praxic Comparison Unit (MPCU): Neural function that permits a comparison of the program of a movement with its effection. Effection Unit (EU): Muscles.

it is postulated that the stimulating model is formed by a long lasting sound and a fixed source. The auditory component of a Stimulating Model is analyzed by the Peripheral Analyzer Unit (PAU), and then by the Specific Central Analyzer Unit (SCAU). The output of the unit unspecifically activates the Kinodynamic Unit (KdU), and specifically other units. This input gives information on the laterality of the sound source, inducing a direct firing of the motor unit controlling the muscles of the inner ears and the motor units of the Kinetic Model Generator Unit (KMGU) that selects a kinogram modulating the activity of the Kino-
praxic Unit (KpU), inducing a conjugated movement of the ears, tending to achieve the “best intensity” of the sound.

The Memory Unit (MnU) analyzes the information and decides which kind of movement is related to it, activating in the KMGU a specific kinogram, a program for a given moment. A new sound or sounds related to a given interesting source, determine the activation of the program for the targeting response in the KMGU. The movement is executed by an activation of the KpU. The feedback information coming from the muscles of the external ears, EU, is analyzed in the SCAU and gives the indicative parameters of the angular position of the sound source. The eye movements start, and simultaneously the muscles controlling the head movements towards the source are facilitated. The feedback information coming from the extrinsic muscles of the eyes indicates the relative position of the eyes in relation to the source. The kinogram activates the KpU corresponding to the head muscles. The head movements induce two types of feedback information: muscular proprioception and labyrinthine reaction, giving rise to the well known postural reflexes. During this period the MPCU regulates the tonus via KdU, the programmation via KMGU, and the execution, via KpU.

As soon as the image of the source falls fully onto the macula, the fixation reflex takes place, giving a maximum of visual information. At the different levels of the SCAU, auditory and visual information are processed and integrated. A new kinetic mnemogram begins to be formed. As soon as the mnemogram is fully developed, the MnU becomes inactivated. An inhibitory feedback from this unit reaches the KdU. The KMGU becomes inactive for the specific program. Inhibitory influences also reach the KpU. The muscles involved in the reaction acquire a resting tonus. During this time the MPCU has received information about the configuration of the virtual movement required. This unit regulates the set of motoneurons which should discharge in the KpU under the influx of the KMGU. Thus each motor neuron of the KpU is under the influence of the KMGU, the KdU and the MPCU. The MPCU can regulate the execution of the movement, because, besides the program for the movement, it receives feed back information from the KpU and from the muscles. Thus, the whole circuit involved in the reaction becomes inactivated.

As long as the Stimulating Model is repeated, the functional state of the nervous system experiments changes which in the final step, when full inhibition of the reflex is produced, can be interpreted as follows: The auditory component of the Stimulating Model is analyzed by the PAU and by the SCAU, the KdU is activated, the KpU induces the contraction of the inner ear muscles, and the KMGU activates in the KpU
the neurons that control the conjugate movements of the external ears. The MnU decides that the sound is known, selects an inhibitory kinogram of the targeting reflex. The KMGU acting on the KpU inhibits the targeting movements in progress, and no more activity is observed.

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