NOVELTY AS A STIMULUS OF SPECIAL REACTIONS

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(Received June 24, 1958. Presented by Active Member of the AMN SSSR V. V. Parin)

Since the time when it was shown that any change in the conditions or experimental arrangement constitutes quite a strong stimulus, the problem has been to find which reactions occur in response to novelty.

It is known that there are stimuli which evoke special reactions, which may be inborn or acquired, as for instance, feeding, defensive, and other reflexes. Also, the most varied stimuli may be effective in eliciting the common reaction usually referred to as the orienting reflex [1-4 and others]. Novelty, as a stimulus, evokes this reaction, whose effector component consists in adopting a position in which the receptor organs are directed towards the stimulus source.

In his last researches, I. P. Pavlov noticed that novelty also brings about a special reaction. This result is shown most clearly in studying the reflex of alertness, or the passive defensive reflex. It was found that under certain conditions novelty brings about a special reaction, the alerting reflex, and that this is accompanied by a generalized reaction – the orienting reflex [4].

Given that there is this response, the problem then arises as to how this complex behavior in response to novelty may be broken down into separate components; it becomes necessary to study the alerting reflex and its relation to the orienting reflex in cases when they both occur simultaneously in response to the same stimulus.

We have based our approach on the fact that in whatever reaction is being performed by the animal, it is always possible to discern a generalized reaction, i. e. one in which the receptor organs are directed towards the position of the stimulus. When other stimuli come into play, the extent to which the orienting reflex is mobilized and directed is less; but when such other stimuli are not present, although only the merest trace may be noticeable, the orienting reflex will always act so as to favor the perception of the usual stimuli associated with the set-up of the experiment.

When a dog is placed on a stand which has been moved to a new position, the limitation imposed on its movements facilitates the development of the alerting reflex. If the stimulus is placed to one side of the animal, it will then be possible to establish a temporary association between the development of the alerting reflex and the mobilization of the orienting reaction. To demonstrate that novelty in the form, for instance, of a new stimulus elicits first of all a special reaction, the most striking effects will be obtained the first few times that it is used in the experiment. Thus, switching on a bell behind the animal, first of all produces the alerting reflex. In the first second of its action, the dog develops the passive orienting reaction. It crouches down, interrupting any movements it may have been making. It is important to note that there is no change in the orienting reaction during the moment of onset of the alerting response. Only after a certain time, which will depend on the particular dog, the head will be turned towards the stimulus, and the animal will listen and watch the spot from which it originated. But even when the bell is rung the second time, as a rule the orienting reflex and alerting reaction occur together.

In order to enable a more precise description of the reaction of a dog to novelty to be made, we recorded the respiration and the electrical activity of the brain. During the action of the new stimulus, the respiration

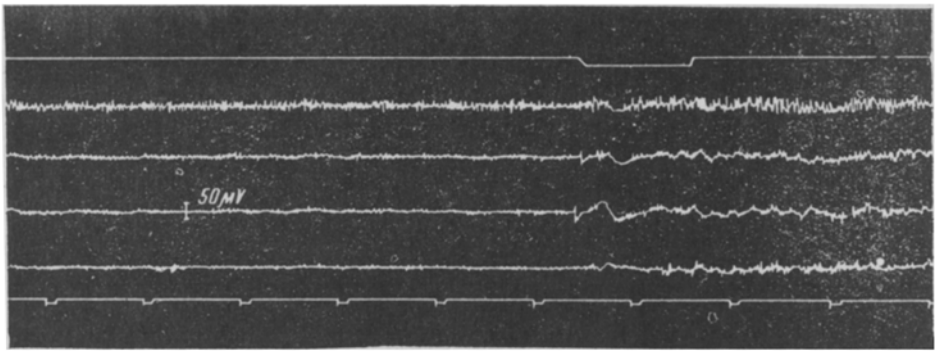

Fig. 1. Increase in the degree of synchronization in response to food being offered in the way to which the dog is accustomed. Electroencephalogram recorded by G. G. Sakhiulina's method.
Curves, from above downwards: stimulus trace; electroencephalogram recorded from premotor region of left hemisphere, sensory motor region of right hemisphere, parietal area of left hemisphere, occipital area of right hemisphere; time marking (1 second).

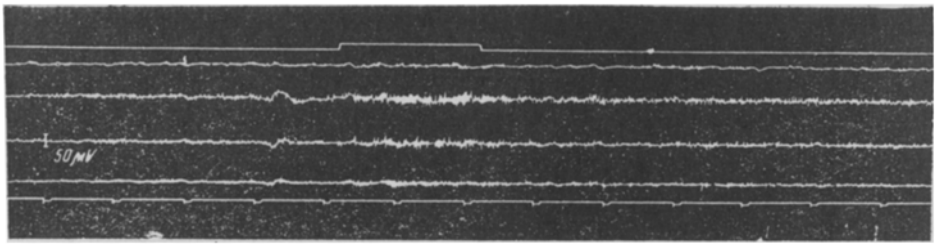

Fig. 2. Increased synchronization on giving new stimulus in unaccustomed setting. First application of the new stimulus – the bell.
Curves as in Fig. 1.

alters. During the first applications of the stimulus, the respiratory component of the alerting reflex consists of an arrest or of a delay in the respiration, and this is observed in most cases in experiments carried out on different dogs.

When a new stimulus is used in surroundings to which the animal is unaccustomed, considerable changes in the electrical activity of the brain occur; they resemble those which are found in the usual set-up when a natural conditioned or unconditioned stimulus is applied, such for example as when the receptor organs are turned towards the feeding trough, and the animal's food reaction to being given rusks occurs. Thus, in Fig. 1, it can be seen that when the feeding trough is offered to the animal, which then begins to eat, synchronized electrical potentials occur immediately. This change occurs in one case when the potentials composing the electroencephalogram (EEG) become desynchronized, and in another case when they become synchronized. In both instances, the manifestation of the food reaction is associated with an increased synchronization of cerebral electrical activity.

The first time that a new stimulus, placed behind the dog, is given, the result is an immediate and considerable variation of voltage amplitude. The EEG corresponding to this experiment is shown in Fig. 2. The electrical oscillations represent a greater degree of synchronization of cerebral electrical activity during the development of the alerting reflex. As was the case with the reaction to being offered food, the degree of the synchronization increases independently of the normal background electrical activity of the brain of the animal in the waking state.

Thus, a single stimulus, either old or new, elicits simultaneously both the generalized orienting and the directed special reaction, for example the feeding or the alerting reaction. Modifications of these experiments showed that the orienting reflex does not inhibit this special reaction. Here we refer to experiments in which

the alerting response elicited by the novelty of the stimulus occurred before a change in the direction of the orienting reflex. In this case, when the direction of the orienting reflex changed toward the side of the new stimulus, not only was there no decrease in the synchronization of the potentials accompanying the unconditioned alerting reflex, but on the contrary there was sometimes even an increase. When there is a change in the direction of the reflex which occurs at the same time as the new special reaction is developed, then again there is no inhibition of the latter. Neither is the electrical activity of the brain characteristic of the special reaction suppressed, in spite of the fact that the orienting reflex is also present.

These results lead us to suppose that the orienting reflex exists side by side with the dominant special reaction, in the form of a generalized complex of central and peripheral processes. Not having any independent function, it becomes a constituent part of the special reaction and acquires the same biological significance as the latter. Thus, with the usual feeding arrangement, the orienting reflex comes to be associated with the food reaction, and enables stimuli belonging to the feeding experience of the animal in the particular experimental set-up to be perceived. In the case when the extraneous stimulus is used and the alerting reaction develops, the orienting reflex then becomes part of this special reaction. In this case it facilitates the perception of extraneous stimuli which have evoked and which will continue to elicit other special reactions composing its inborn and acquired experience of defence in times of danger.

As we have already pointed out, the transition of the orienting into the alerting reflex becomes possible after this special reaction has come to form part of the effector make-up. This fact allows us to consider the orienting reflex as an accessory complex of the central and peripheral processes. Here we have in mind the very closely related physiological mechanism of the integration of the generalized complex and the special reflex into a single reaction of the animal which has a unique biological significance. It may be supposed that this mechanism is brought about by a union of the orienting reflex with the centrally organized special reaction whose cortical stimulation is at a higher level than that of the other special reactions.

The directional quality of the orienting reflex, as for instance toward the feeding trough with the food, is due to the dominant part played by the food stimulus; this direction changes when a stronger stimulus passes to the central representation of another reaction, for example the alerting response. The relationship between the excitability of operative and potential special reactions is an important physiological factor [1, 2, 4, 5, 7, and others]. This relationship may undergo changes, and at any one time it determines with which special reaction the accessory complex of central and peripheral processes may become united and into which one of them it may enter so as to form part of its composition.

We have described the results of the first application of a new stimulus, when the excitability, that of the alerting reflex, is above threshold and the level of excitability of competing special reactions is low. With repetitive application of the new stimulus, when no danger to the animal follows but when food is given, the level of excitation of the alerting reflex becomes reduced, and the balance alters in favor of the food reaction. There is no external sign of the alerting reflex, so that this becomes a potential reaction. If its level of excitability remains subthreshold the whole time, then there is no change in the direction of the orienting reflex i. e. the latter produces an "extinction". After repeated application of the new stimulus, the organism is occupied in executing the special food reaction. The orienting reflex forms a major part of this reaction, and enables the sense organs to be placed so as to receive the appropriate stimuli from the food.

However, the alerting reflex, which has now become a potential reaction, remains at a comparatively high subthreshold level for a definite period occupied by experiments. This is perfectly understandable. A new stimulus, which elicits an alerting reflex and which is reinforced by food, forms a temporary connection with the food reaction. That is to say it comes to acquire a two-fold biological significance and becomes a common stimulus for two functionally incompatible reactions. On the one hand, the new stimulus acts on the inborn alerting reflex, and on the other, according to the law of temporary linkages, it stimulates the food reaction.

During the period of action of a single stimulus, two opposite processes are started, with the result that the cortex comes to exercise a control over two competing reflexes. At this time, in the experiments, both the extent of the inhibition of the alerting reflex and the degree of excitability of the conditioned food reaction show great variations; the EEG becomes desynchronized, the autonomic components are stressed, and the orienting reflex is more clearly shown.

During the period of the opposing actions in the cortex, two kinds of excitation occur, each of which has its own special rhythm. Hence the desynchronization of the EEG, the strain on the autonomic components, and the increased orienting reflex are expressions of this conflict affecting cortical coordination, i. e. of the conflict between the suprathreshold excitation of the manifest reaction, for example the food reaction, and the barely subthreshold excitability of a potential reaction, for example the alerting reaction. In later experiments, this interaction results in a considerable shift in the relative excitabilities in favor of one of the two competing reactions.

At this stage in the development of cortical coordination, a stability in the conditioned food reaction, a synchronization of the EEG, a return to normal of the autonomic components, and a reduction in the strength of the orienting reflex, are all observed.

Thus, the changes described are indications of the coordination which has been effected, i. e. of the suprathreshold excitability of the actual food reaction and the considerable reduction in the subthreshold excitability of the competing alerting reaction, when stimulation of the latter has little or no effect on the EEG.

The alerting reflex does not always occur in response to a new stimulus. According to the type of nervous system, the strength of the new stimulus, and other conditions, novelty may cause other inborn or acquired special reactions such as the freedom reflex and investigatory, defensive, and food reflexes to occur. However, in all these cases, the relationship between the orienting reflex and the special reaction shows the same features which we have described as occurring during the alerting reaction.

The results of our investigations have led us to conclude that any change in the normal conditions of the experiment constitutes a stimulus which produces one or another special reaction, a reaction which reflects the animals inherited or acquired experience. The orienting reflex also develops as a response to a novel stimulus, but it is only of subsidiary importance; both in response to stimuli to which it has been accustomed as well as to new stimuli, it occurs at the same time as a special reaction, becomes part of its central organization, and comes to share its biological significance (food, defense, search, etc).

The orienting reflex is preserved during the whole of the animal's waking life. This is well shown in man. The orienting reflex represents the physiological basis of attention.

It is known that attention may change in direction and intensity, but it never becomes extinguished or eliminated in the waking state.

We have put forward the idea [5] that the central influence of the orienting reflex consists of an extra strengthening of the special reaction of which it forms a part. Therefore, the orienting reflex speeds up the development of cortical coordination, with the result that either a new dominance develops, or the old one remains. It accelerates the development of coordination, both during the stage when the special reaction is being elaborated, and also in the stage when it is becoming consolidated; this is the stage at which the stabilized reflex is being destroyed by inhibitory effects resulting from another special reaction evoked in turn by an extraneous stimulus.

The fact that the animal reacts to the novel situation by special reactions which have been tested in its previous experience is of great biological significance. This direction of the processes in the central nervous system results in a rapid adaptation to changing circumstances in the environment. If the special reaction developed in response to the action of the stimulus is not adapted to the particular experimental arrangement, or if it does not produce the appropriate effect, then a modification of the innate or signalled significance of this stimulus becomes modified in accordance with the changed circumstances, i. e. a new special reaction emerges.

SUMMARY

The stimulus which is of nutritional significance employed in the usual environment of feeding causes simultaneously a general reaction (orientation reflex) and the corresponding food reaction. A new stimulus, especially employed in unusual conditions, causes a general (orientation) reaction and the reflex of biological caution. Novelty, as a stimulus, causes special reactions reflecting congenital or acquired experience of the animals. Orientation reflex is preserved all the time while the animal is awake. However, its direction is changed, which is shown by the presence of a dominating special reaction. Orientation reflex is included in the central organization of a special reaction and has a common biological significance with it (food, defensive, etc.).

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