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A New Method of Physiological Investigation of Recent Memory in Animals

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According to the vast evidence accumulated in recent years we can distinguish two different kinds of lasting effects produced in the central nervous system by stimuli impinging upon it, effects which are usually referred to as memory traces. One of these kinds has a very longlasting, and probably even permanent character and is referred to as stable memory. The other kind lasting only for a number of seconds, minutes, or hours is called, in contrast to the first, transient or recent memory. We have some evidence that these two forms of memory differ not only in their phenomenological aspects, but also in their physiological mechanisms. The first form is probably due to some stable micromorphological changes in the interneuronal connections (outgrowth and multiplication of axonal endings [3]), whereas the second form is, at present, generally attributed to the reverberating chains of neurons, activation of which may persist for a relatively long time after the actual stimulation of the given group of neurons [1]. According to this hypothesis the first form of memory may be called static, and the second dynamic.

It is a striking fact that the physiology of higher nervous activity (or physiological psychology, as it is called in America) has so far been concerned almost exclusively with static and not dynamic memory. Whether we have to do with classical or with instrumental conditioned responses of various sorts, we are chiefly concerned with establishing excitatory or inhibitory conditioned reflexes and with studying their properties under various experimental conditions. The only method in which the phenomena of recent memory were explicitly studied has been so far the method of delayed responses, introduced in behaviouristic psychology by Hunter [2]. In this method the experimental setting is such that one of two or more sources of food is baited in front of the animal and then, after a number of seconds or minutes, the animal is released and must remember where the food was hidden. As shown in many experimental studies the

recent memory involved in the delayed response method concerns on] directional cues, i.e. the memory of where the animal should go after the delay. But we have every reason to believe that probably all sorts of exteroceptive stimuli (acoustic, visual etc.), when impinging upon the central nervous system, throw into activity certain reverberating circuits of neurons which are responsible for the reversible, shortlasting memory of these stimuli.

The problem arises, what should be the adequate method of investigation of recent memory traces of particular exteroceptive stimuli in animals. It may seem that recent memory should be involved in all forms of differentiation of compounds composed of successive stimuli differing only in their sequence, since, in order to recognize a successive compound, one must keep its components in mind. But, in fact, it is not so: it is sufficient for the animal to differentiate between the differing element of the compound (e.g. between the first ones in differentiation between S_1, S_2, S_3 and S_2, S_1, S_3, or between the last ones, in differentiation between S_1, S_2, S_3 and S_1, S_3, S_2 tc.), and to neglect the rest of them, in order to solve this test; and so the task is reduced to the differentiation of simple stimuli in which only conditioning, i.e. stable memory, is involved.

Other phenomena in which the recent memory of stimuli seems to play an important part are the so-called trace conditioned reflexes. But here too, the animal does not necessarily react to the trace of a given stimulus since the reaction may be determined by the general orientation evoke by this stimulus and preserved after its cessation. This possibility is: supported by the fact that, after the trace conditioned reflex has bee established, the traces of quite different stimuli produce the same effect [4].

As a last example of the only apparent significance of traces of the stimulus for the conditioned response, we shall consider the conditioned inhibition. The experiments with conditioned inhibition may be arranged in such a way that a conditioned inhibitor and a conditioned stimulus are applied not in overlapping sequence but the first may precede the latter by a number of seconds. This compound, when not reinforced, acquires an inhibitory character, while the conditioned stimulus acting alone is positive. It would seem that the recent memory of the conditioned inhibitor is indispensable for the solution of this task. But here again, according to our experience, the conditioned inhibitor evokes a quite ostensible negative bodily attitude which lasts for some time and is the very cause of the negative response to the conditioned stimulus acting against its background.

As may be seen, all these experiments do not provide unequivocal test of the existence of recent memory of the stimulus itself, because the reaction may be based on quite different cues or their traces. Therefore, we propose the following type of test which seems to be free from this defect.

We apply a number of stimuli: S_1, S_2, S_3, etc. of a given analyzer, which differ only in one modality (e.g. tones of different pitches) according to the following schedule: the stimuli are presented always in pairs one after another with a short interval (ranging from 0 to 10 seconds); when the same stimulus is applied twice in succession, such a compound is reinforced (either in classical or in instrumental conditioned-reflex setting);
when the second stimulus differs from the first, the compound is not reinforced. In other words, the compound S_x S_x is positive, while S_x S_y is negative, whatever x and y are, provided that $x \neq y$. And so, only a comparison of the second stimulus with the first can provide the animal with the clue indicating how to react. The correct response is possible only if the animal retains the trace of the first stimulus when the second is acting. By this method all sorts of stimuli, and their various characteristics (pitches of tones, intensities of sounds or lights, colours, shapes of visual figures, tactile stimulations of various places of the skin and many others) can be successfully investigated in respect of the transient traces they leave in the nervous system.

Since the proposed test is clearly specific for the investigation of recent memory of stimuli as such it may be applied to another problem of the physiology of recent memory, namely the problem which parts of the brain are responsible for the preservation of dynamic memory traces for a given analyzer. We have now a great body of evidence showing that stable memory traces of a given modality of stimuli, manifested e.g. in differentiation of pitches, of intensities of sounds or lights etc. are strikingly resistant to large cortical ablations, so much that the problem arises whether the cerebral cortex is really indispensable for their occurrence. As far as recent memory is concerned, surely this is not so: even very limited lesions in a given projective area or the neighbouring associative areas are sufficient to destroy the recent memory of respective stimuli totally and irreversibly. Thus, by introducing this method a vast field of the physiology of recent memory of both normal and brain-damaged animals is set open for investigation.

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