

DISCUSSION
INTERNAL SECRETION IN LEARNING
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Non-psychological writers, and many psychologists, assume that emotion has a direct influence on action, and in particular, that pleasure (or satisfaction) and pain (or dissatisfaction) are instrumental in the formation of habits. Certain writers, however, have objected to this assumption on various theoretical grounds, the most important of which, at the present time, is the alleged fact that no detailed mechanism is discoverable or has even been suggested, by which the effects of emotion on action might be mediated. This omission I have had in mind for several years to supply by a hypothesis which seems to offer grounds for experimental test: but as I shall be able to carry out the tests on only a few points, it seems proper to outline the hypothesis for the consideration of others who may be experimentally interested in the matter.

The hypothesis I have in mind is a logical outcome of the view to which some of us were earlier forced concerning the emotions, namely, that in the important bodily changes which are commonly called "expressions of emotion" (and which I, following Lange, would insist *are* the emotions), the activities of certain, probably all, of the endocrine glands play a part. Five years ago I assumed that this would be found true of the "major emotions" (or what are sometimes called "emotions" as distinguished from "feelings"), as Cannon has so admirably shown. At the present time, I have no hesitation in adopting it as a working hypothesis for the "feelings" of pleasure and pain, and all other definite affects.

There are certain cases in which the effect of pleasure in "fixing" a reaction can be explained by the immediate repeti-

tion of the act, or by the dwelling in thought on the act, which is probably physiologically equivalent to a repetition. These cases come under the heading of *repetition* or *frequency*, which, so far as I know, no one doubts to be an important factor in association or habit-formation. The cases which cannot be subsumed under this head are the ones in which the efficacy of pleasure has been challenged, and these are the ones with which we are at the present moment concerned.

If pleasure (to neglect pain for the moment) is directly connected with a change in internal secretions, and if internal secretions may act on the nervous mechanism (both of which conditions are possible), we have in this aspect of pleasure a possible means of influencing habit formation. Since the reaction which we suppose to be "fixed" by pleasure precedes rather than follows the pleasure; or at least precedes the hedonic secretory effects—as we must allow a time interval for the secretion to be carried in the blood stream to the effective locality—the influence of whatever hormone is involved is retroactive, i.e., it will act on a pathway over which discharge has occurred in such a way as to make discharge over that pathway more probable in the future than it was before.

In brief, the obviously suggested theory is that the nervous discharge leaves an arc or certain important points in the arc in such a condition chemically, that a certain substance (hormone) may a few moments later "fix" it. Artificial as this theory sounds at first, I believe it is worth putting to the test.

I might point out familiar observation, and data from the experimental investigations of learning, which fit this working hypothesis. There are many pertinent cases. I believe however that this procedure would not be legitimate, since the observations which support my hypothesis were not made with this hypothesis in view, and hence the strong backing they afford may be more apparent than real. The important thing is that experimenters should hereafter keep the hypothesis in mind, and observe specifically in future work the data which have direct bearing on it.

The particular efficacious hormone which is liberated in pleasure

is conjectural. It can hardly be adrenalin, for this, as Cannon's experiments seem to show, is the endocrine correlate of excitement, which is not conducive to habit formation, but rather to the breaking down of habits. It must be a secretion, which like adrenalin, is discharged directly into the blood (not indirectly through the lymph channels), by which it is carried to the "centers" in which habits are formed, i.e., in which the critical synapses lie: unless indeed the route may be still more direct as seems hardly possible, even from the pituitary body. It may be, however, that the secretion is not formed in a "gland" proper, but in some tissue whose primary function is not secretion.

The effects of pain, in preventing the fixing of the preceding acts, may not be so specific as are the effects of pleasure. It is possible that adrenalin or some other active principle is the negating agent here, but it is also possible that the effects are produced by the setting up immediately of more powerful reactions which disturb the interconnections left by the preceding algesogenic reaction. By "pain" is here meant the affective content usually (and properly) described by this term, ignoring the unfortunate psychologists' confusion between this and certain specific sensations.

The implications of the theory which admit of experimental verification, or the reverse, are numerous. Those in which I have been most interested in are the following.

1. Actions performed shortly before the reaction which produces the "satisfying" result, and actions *immediately* following it, would be fixed, along with the act itself. The normal pause in activity following the "satisfying" reaction (where the reaction itself is not immediately repeated) is probably a useful phenomenon.

2. If an animal, in solving a simple "problem" makes a short series of reactions, including a number of "wrong" acts and terminating with the correct (satisfying) act the probability of repetition of the "wrong" acts is as great as that of the "right." But after the solving several times, the probability of the "right" act becomes greater than that of any "wrong" act unless a

"wrong" act has been in every series. In that case, the animal should eventually repeat the "right" act uniformly preceded by the "wrong" one.

3. If the apparatus is so disposed that satisfaction is not given to the animal until several "wrong" acts have been done after the act which really makes the satisfaction available, learning will be made especially difficult, unless the animal is able to make a conceptual analysis of the problem.

4. In a problem involving the necessity of a definite series of actions for its solution, and allowing the performance of "wrong" acts at various points, the elimination of wrong acts will follow no law except that of probability, based on a number of repetitions. Of the wrong acts which have been done up to a certain point in the learning, those which have been done the fewest times will be eliminated soonest.

5. In the human animal, in spite of the non-emotional factors which enter most learning problems, the hormone factor should be discernible.