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PRINCIPLES OF SELECTION IN ANIMAL LEARNING

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In comparative psychology, pleasure and pain are generally regarded as the sole selective principles in learning; the successful act is 'stamped in' by the pleasure, and the errors are eliminated by the unpleasantness. In opposition to this prevalent view, this paper will advance certain objective principles of explanation. Before stating these factors, we shall develop several distinctive features of the problem situation which are important from the standpoint of this paper.

The sensory situation which confronts an organism is a highly complex one. In a problem box, the stimulus consists not only of the food, but the problem box, the larger containing box, the table top upon which these are placed, oftentimes the experimenter and various objects in the room, and the motivating hunger stimulus. It is irrelevant whether hunger be due to the presence of a material stimulus or to the absence of a stimulus customarily present. Either sensory condition constitutes a stimulus from the psychological standpoint. Hunger is a persistent irritating sensory condition which arouses activity until some of the acts succeed in altering or alleviating the disturbing condition.

The animal does not react to this complex situation as a unitary whole, as a single stimulus. He reacts to it selectively, and as a series of stimuli. There is a circular interaction between the sensory stimuli and the animal's movements. Each act modifies the stimulus in some respect, and the change of stimulus in turn modifies the act. The motor excess, or the

variability of response to a problem, can be explained to a large extent in this manner. Every movement generates distinctive kinesthetic and cutaneous stimuli. The intensity and direction of the food odor varies with practically every movement. The visual situation differs for every attitude and position of the animal. Cutaneous elements may be added or subtracted from time to time. The successful act introduces gustatory elements and modifies the hunger stimulus. The motor effects of these sensory changes differ in degree and kind; they range from the extreme of strengthening and accelerating the act to its complete suppression due to the initiation of an antagonistic act. What these motor effects shall be depends upon the nature of the resultant stimulus and the animal's organization in reference to it. An act that brings an animal in close proximity to the food is accelerated not because of pleasure but because the animal is built that way. A resultant electric shock will suppress an act through the initiation of an avoiding response. The negative response is to be explained in terms not of unpleasantness but of the animal's innate organization to such a stimulus.

The stimulus to which the animal responds also changes radically from trial to trial throughout the learning process. The animal gradually ignores some aspects of the sensory situation and begins to respond to other aspects which at first were not noticed. In a problem of visual discrimination, a rat reacts at first to the food odor, the exits, the sides of the box—in fact to most anything and everything except the visual objects to be discriminated. He generally makes considerable progress in mastering the problem in terms of position and alternation before his behavior is affected by the crucial stimuli. While the series of responses to a problem are an expression of the animal's innate and acquired organization in reference to that sensory situation, yet these acts are *rarely* aroused by the crucial stimuli themselves. Hence most problems at least involve to some degree the formation of a new association between the crucial stimuli and acts which were originally made in response to other aspects of the sensory situation. It is not our purpose to discuss the method and conditions of forming

new connections. We merely note the fact that they do tend to become established. We have given, then, a system of connections between acts and the various sensory aspects of the problem; some of these connections are new while some represent the previous organization of the animal. The further progress of the learning consists of the preservation of some one, or group of these connections and the elimination of the others.

Selection and elimination are the diverse effects of a single process or mechanism. All connections tend to be preserved; all develop in strength and functional efficiency during the learning process, but their development proceeds unequally. The unsuccessful tendencies are not eliminated in the sense of being torn out by the roots; they are eliminated only in the sense of not being aroused in that situation. The strongest and most prepotent tendencies of the group function first and dominate the situation. The successful act is selected because it finally becomes the most prepotent in the group; all others are eliminated, or better are 'suppressed,' because of their lesser development in functional efficiency.

The problem of determining the various principles of selection and elimination thus resolves itself into a search for those factors which favor the retentive development of the successful act at the expense of the many failures. The principles are relative recency, relative frequency, and relative intensity. We shall develop our conception by applying these principles to the various types of problem. For our purposes, all animal problems may be divided into three classes: (1) that involving a series of simple acts directed toward the stimulus, the final one of which is necessarily the successful one. This type is illustrated by a problem box opened by pulling upon a cord suspended in front of the door. (2) The second type is represented by the maze or a complex problem box involving a fixed series of lever manipulations. The successful act is a complex whole composed of elements which were originally separated from each other by many useless acts. The process of learning involves the elimination of the useless and the serial coördination of the various elements, only one of which can be the final one of the series. (3) The third type deals with the inhibition of some instinct or habit.

All three principles are effective in the first problem. The successful act tends to occur more frequently during the learning than any of the useless acts. The successful act must occur in every trial, while as a matter of fact any useless act on the average does not occur in more than half of the trials. It is possible, however, for some error to be repeated a number of times in one trial. Since the successful act can occur but once per trial, it is thus possible for some error to be repeated throughout the learning process more frequently than the successful act. Why should not this error be selected? Our answer is that this fixing of useless acts does as a matter of fact often occur in both animal and human learning, and the phenomenon supports rather than disproves our conception. As to the final elimination of such useless acts, we are forced to contend that they never would be eliminated on the basis of frequency alone. Their final elimination is due to the coöperation of the other factors.

The successful act is intensified and accelerated by its sensory consequences to a greater degree than is any other act. This act possesses a number of peculiar and distinctive sensory consequences. The string in common with most other parts of the apparatus offers some resistance to attack but its behavior is unique in that it suddenly gives way to the pull. The sudden opening of the door is a surprising and unusual visual and auditory result that not only attracts attention but which often excites a certain timidity. After entrance, the box is sensed from the inside—a rather striking effect to those animals equipped with some disposition either to avoid or to seek such enclosures. The intensity of the food stimulus is increased in a more pronounced manner than heretofore, while the new elements of taste and mouth contact are added. The final and most important sensory consequence distinctive of the successful act is the alteration of the hunger aspect of the sensory situation. That the successful act is characterized by distinctive and important sensory effects is evident from the fact that the only real criterion of a success as opposed to an error or failure depends in the last analysis upon the nature of the sensory effects of those acts. Not only does the successful

act result in novel and significant sensory changes, but there is evidence on the motor side of their stimulative efficiency. The final series of acts beginning with the downward pull on the string represent the maximum of tension, excitement, vigor, decisiveness and acceleration. This change in the character of the animal's behavior is very apparent and striking though rather difficult to measure in any quantitative terms.

The successful act is necessarily the final one of the series—the most recent one. The effectiveness of this factor can naturally be inferred from human experiments. Any explanation of its efficiency is more difficult, but this difficulty obtains for the human realm as well. Although we are concerned more with matters of fact than with explanation, we may mention three possibilities. The successful act stands in a closer temporal relation to the subsequent trial than does any of the failures, and we can assume that the retentive effect of any act is inversely proportional, other things being equal, to its age. This disparity of age, however, would seem to be negligible except in those problems where a number of trials are given in immediate succession. Recency may also be interpreted as temporal contiguity to the food stimulus. In this sense the factor would seem to be a special case of the intensity principle. Again, the successful act may be favored because it is the *final* one, rather than an act which is followed by further activity. It is known that any activity interferes with the gradual setting or fixing of the retentive effects of any immediately previous act. The retention of all useless acts is thus retarded by the necessity for further activity, while the final or successful act is relatively favored by the absence of such subsequent distractions.

The maze is taken for the second type of problem. The effective factors are frequency and intensity. During the first trial the segments of the true path will be traversed more frequently than the cul de sacs, and this disparity must rapidly increase from trial to trial. Let *X* be a blind alley, interpolated between two segments of the true path, *A* and *B*. Let the animal be running forward through segment *A* leading to *B* and *X*. Since the probabilities of entering *B* or *X* are even in

the long run, and X can be entered on the forward journey only through A , it follows that A will tend to be traversed twice as frequently as X . What is true for A and X will hold for any segment and its succeeding cul de sac on the forward journey. The same relation will also apply for any returns toward the entrance box. In the latter case, however, the ratio of frequency in favor of the true path will be increased owing to the fact that an animal in these returns very rarely leaves the true path.

The usual distinction between the true and the false paths in a maze is wholly meaningless from the standpoint of a learner, be he animal or human. Such a distinction can arise only as the maze is mastered. From the standpoint of the immediate sensori-motor situation in which the animal is placed, the true path and the cul de sacs are to be distinguished from each other on the basis of the degree to which they impede or encourage the animal's activity. A blind alley is but a sensory obstacle or impediment to the animal's activity; it means hesitation, caution, investigation, or disastrous sensory consequences. The true path presents fewer obstacles; it offers greater encouragement to freedom, continuity, rapidity, and vigor of motor expression. The difference is merely one of *degree*. The blinds check, thwart, and suppress activity more than does the true path, while the latter encourages and facilitates activity more than does a blind alley. The principle of relative intensity is here effective; acts are selected or eliminated according to whether the sensory consequences tend to facilitate and intensify them on the one hand, or to disrupt and suppress them on the other.

For the third problem, let us assume that an animal is reacting positively to some food object sensed at a distance. Let the conditions be so arranged that any contact with the object will result in an electric shock. The animal thus comes to the problem endowed with two ready-made connections, a positive response to the object, and an avoiding reaction to the pain stimulus. We shall term these connections $S-M$, and $P-A$ respectively. The functioning of the first tendency inevitably results in the arousal of the second and the two are

brought into conflict. This second disposition is necessarily the stronger or it would not dominate in the conflict. In this situation, the second act A becomes connected with some sensory aspect X of the object, and the new connection $X-A$ is formed. The only essential requirement of this stimulus X is that it be sensed at a distance. The further task of learning now consists in the development of $X-A$ to a point where its functional efficiency is greater than that of $S-M$. Its strength does not need to exceed that of $P-A$, because the successful functioning of $X-A$ will prevent the animal from receiving the pain stimulus. All three of our principles favor the connection $X-A$ over that of $S-M$. The avoiding response is the more recent. The retentive development of the positive response is interfered with by this violent interruption of the pain stimulus and its motor results. The latter disposition is, however, subjected to no such distractions. The negative response is the more intense and vigorous one. Because of its greater recency and intensity, the resulting disposition is so susceptible that it is likely to be aroused and become connected with almost any opportune stimulus connected with the total situation. What this stimulus shall be and the number of trials necessary to establish an efficient connection will depend upon the nature and intensity of the possible stimuli and the organism's capacity to sense them. After the new connection approximates the old in functional strength, the factor of frequency will become operative and assist in the final stages of the elimination.

In considering the efficiency of these principles, possible critics must consider that they can work in cooperation, and that their effects are also cumulative from trial to trial. Neither does it follow that this cumulative effect proceeds according to an arithmetical progression. Neither do we contend that these are the *only* possible principles; the theory makes no pretense of completeness and self-sufficiency. These principles are also designed to explain the *mere fact of selection*, why an act with certain attributes invariably survives and why all other acts are eliminated or suppressed. There is no pretense of an explanation of *all* aspects of the learning process.

We emphasize this point because we wish to avoid the charge that our set of principles is obviously incomplete and inadequate to an explanation of the learning process as a whole. To illustrate, it is known that the 'temporal distribution of the trials' is a very important condition of learning in both the human and animal realms. But this factor influences merely the *rate* of selection; it determines in no way *what* acts are selected and *what* acts are to be eliminated.

Our conception may be briefly compared with the algedonic theory in several respects. The algedonic theory generally regards pleasure and unpleasantness as the sole principles of selection. We deny this adequacy in both the human and animal realm; we deny the assumption that all eliminated acts are unpleasant and that all surviving acts are pleasant. Such a conception does not allow for the existence of neutrally toned activities. Many useless and trivial acts are frequently selected. Acts both useful and useless may become fixed and the learner may remain in blissful ignorance of their very existence, to say nothing of being aware of their affective character. Many acts are learned which are distinctly unpleasant during the early stages at least. Pleasant activities often fail to reach the habit stage. With our conception these anomalous cases are readily explicable.

In the animal field with which we are specifically concerned, the algedonic theory meets the difficulty of an objective criterion of these subjective conditions. Obviously these selective factors must be validly inferred from certain aspects of the objective sensori-motor situation. Some discussions seem to ignore the issue. Others apparently commit the fallacy of utilizing the phenomenon of selection itself as the criterion of pleasure. This is a case of reasoning within a circle. The selection of a certain act is observed and noted. The conclusion is reached that this act was pleasurable because it was selected, and after the existence of pleasure is thus determined, the further conclusion is advanced that the act was selected because it was pleasurable. Such an explanation is merely verbal and any alleged knowledge obtained is purely chimerical. Any valid algedonic theory must choose as its criterion of

pleasure some fact or aspect concerned with the learning process other than the fact of selection itself. Moreover, this fact or aspect which is to be utilized as the guarantee of the existence of pleasure must be one which can be observed, studied and described without any reference whatsoever to the fact of selection. The difficulty of determining such an objective factor and of securing any general agreement upon its validity is readily apparent. Moreover, the law of parsimony would suggest that this objective factor be utilized as the selective agency itself rather than as a mere index of the causal principle.

Any theory is in duty bound to attempt some rational connection between its explanatory principles and the phenomenon of selection. The algedonic theory meets difficulty in this respect. The affective processes must be so conceived that they can exert some causal influence upon the *sensori-motor* activities involved. We do not contend that this difficulty is necessarily insuperable. We merely refer to the fact that no conception has won any general acceptance. Moreover, the algedonic theory necessitates a double mechanism. Pleasure must increase retentive development, while unpleasantness must check and decrease it. Elimination is thus not a mere matter of suppression but a tendency which operates to tear out connections by the root. In opposition to these difficulties, our conception offers a single mechanism for both selection and elimination, and one which is in harmony with generally accepted principles of psychology.

Supporters of the algedonic theory may admit our positive contentions, but urge that there is no necessary antagonism between the two views, that the two can and should be combined. Selection would thus be determined by the recency, frequency and intensity of the pleasure. Such a combination seems plausible at first thought, but a careful analysis will show a combination is impossible. Either the affective processes are the sole selective principles and the objective factors play the subordinate rôle of determining the *rate* of selection, or the objective factors are the real selective agents while the affective elements are mere useless luxuries having no function whatsoever. The situation offers no opportunity for the straddler.