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AN EXPERIMENTAL STUDY OF THE
STIMULUS-FUNCTION

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PROBLEM

Despite the fact that the stimulus-response formula is an integral feature of current psychology several writers have recently indicated great dissatisfaction with that formula. Typical is the position of Klüver (11), who writes "that everybody interested in determining the actual responses of an animal as elicited by stimulation must dispose of the stimulus-response formula, since it is not only misleading and incorrect but positively harmful, inasmuch as it keeps us from finding out what the responses of the animal are". This attitude is based upon his studies in "equivalent stimuli" (9, 10, 11).

It is questionable whether this work on "equivalent stimuli" has really taken into account what a stimulus is. Kantor (8) has pointed out that a closer analysis is required of the concept of stimulus-response and has suggested that perhaps we should not regard an object as a stimulus, but rather the stimulus as a function localizable in an object. The assumption may be made that a response or a configuration of action is not correlated with an object but with some function of an object in an interactional situation. An experimental demonstration of the Stimulus-Function of objects is found in the well known conditioned reflex experiments of Pavlov (18). The Stimulus-Function inherent in a piece of meat in the case of a dog is transferred or built up in a metronome sound, a buzzer, a black square, etc., so that these latter contain functional stimuli that elicit a salivary response.

Before proceeding to a more detailed description of the present problem it is well to consider the lines of work which may be regarded as its background. There are in general three of these: (1) Certain studies in the general field of learning; (2) Experimentation to determine "brain mechanisms"; (3) And the more recent work on "equivalent stimuli".

(1) The first class includes studies which bear on what Köhler has called the "Transposition" phenomenon. Hunter (5) trained rats to make discriminatory reactions to sound and silence and found that some of the animals reacted correspondingly to substitutions of light and darkness. Watson and Watson (23) negatively conditioned a child to a rat and found that it made almost equally intense

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fear reactions to a dog, a pigeon, a fur collar and a Santa Claus mask. Lashley (14) trained animals to react positively to one of two "stimuli" and found the animal would react correspondingly to a stimulus of a new pair of the same class. Köhler (12, pps. 216-217, 302-303), in his "transposition" experiments, found that chicks trained to react positively to medium gray when medium and light gray were presented, responded positively to dark gray when dark and medium gray were presented. He obtained substantially the same results with apes when they were presented with sizes and hues. Dunlap, Gentry, and Zeigler (2) report that when rats are trained to move between two adjoining compartments in response to electric shocks the same behavior is elicited by auditory stimulation. Wheeler and Perkins (20) have reviewed several studies (4, 13, 21) similar to Köhler's work in "transposition".

(2) The second class of studies were made with the avowed intention of gaining a more detailed picture of what has been called "brain mechanisms". Pavlov (19), working with dogs, found what he called "initial generalization", namely, that there is a smaller excitatory effect with an increase of distance from the point of original stimulus. Loucks (18), in a recent critical repetition and revision of Pavlov's work, finds no evidence that the initial stimulation of more distant spots results in smaller secretions than *loci* nearer to the originally conditioned place. Lashley's (15, 16) two well known studies were made with rats and dealt with form discrimination. Klüver's (9, 10, 11) extensive work with monkeys on the "basic mechanisms of animal behavior" will be mentioned later under the heading of "equivalent stimuli". Franz (3) trained subjects to identify given geometric forms when presented to given peripheral areas. After learning, these forms were presented to other peripheral areas equally distant from the fovea and it was found that the results were only slightly affected. Leeper and Leeper (17), interested in proving that learning involved large dynamic neural connections rather than specific ones, presented one group of their subjects with varying stimulatory materials (mazes, melodies, rhythms) and the other with stimulus objects which were not varied. They found the rate of learning for the varied and unvaried material was approximately the same.

(3) The third class of studies, on "equivalent stimuli", may in general be said to have grown out of the work of Lashley (14) mentioned above and out of Köhler's "transposition" experiments. Two somewhat different types of procedure have been employed in these "equivalent stimuli" experiments. The first is exemplified in the work of Lashley (15, 16) and Klüver (9, 10, 11), where the subject was trained to respond to one stimulus which after learning was replaced by a different one to determine whether the same reaction would be produced. In this attempt to determine in some

detail the nature of the basic mechanisms in animal behavior, it was found that stimuli may be modified radically without effecting their "equivalence". The second type of procedure is illustrated in the work of Franz (3) on peripheral stimulation mentioned above.

What the Gestaltists (12), Lashley (15), Klüver (11), and Leeper and Leeper (17) mean by "equivalent stimuli" is that different objects elicit the same response within certain limits and under certain conditions. This work and the studies described above demonstrate, as Kantor (6, Ch. II) has held for some time, and as Klüver has more recently pointed out, that there is no definite way of correlating stimulus object with response.

We agree with Klüver and other protestants that the present interpretation of a psychological stimulus as a stimulus object is grossly unsatisfactory, but we feel that a reinterpretation of what is meant by the stimulus-response mechanism is required. The present study is directed generally at an analysis of the fundamental stimulus-response phenomenon in human behavior. Specifically, this is an attempt to obtain a more adequate description of psychological stimuli in terms of Stimulus-Functions rather than in terms of stimulus objects. It is our observation that a stimulus-response situation is essentially a single behavioral phenomenon. Obviously, any analysis of this phenomenon is a logical or artificial one, the value of which depends upon its adequacy as logical technique for handling psychological data.

On casual observation the single behavioral situation involves a biological organism functioning as a whole and stimulus objects with physical properties. Closer observation reveals that when the organism functions psychologically (as distinguished from its physiological functioning) it does so in relation to an experiential history that genetically endows the physical stimulus and its properties with a functional stimulus value. The fundamental stimulus-response mechanism involved in psychological phenomena is conceived as a dynamic interactional affair between the responding biological organism with an experiential history and the object which is a *locus* for the stimulus function.

It is the validity of this working hypothesis that we have attempted to investigate. To this end stimulus-response phenomena were contrived in the laboratory using human subjects and carefully prepared stimulus symbols unfamiliar to the subjects. These were brought together under laboratory conditions of interaction, so that prescribed psychological stimulus-response phenomena were set up. An attempt was made to investigate the *locus* of the Stimulus-Functions as set up in nonsense stimulus symbols. Investigated were the extent to which the several stimulus symbols could be modified before established stimulus-response relations were affected. This was done under two conditions: (1) the progressive varying of

learned stimulus symbols to points at which the prescribed functional stimuli broke down or failed to operate; and (2) the progressive varying of inoperative stimulus symbols back to points where the prescribed functional stimuli resumed operation.

EXPERIMENTAL

Half of the stimulus symbols used were arbitrarily designated as "right" and the other half, mirror images of these, as "wrong". These materials are shown in Fig. 1. Between these opposite stimuli and human subjects a prescribed response \longleftrightarrow stimulus-function situation was to be contrived. The peculiar needs of the problem called for varying the "right" stimulus symbols until they no longer operated as in the learning situation. It is this point of breakdown in response that we would regard as demonstrating the *locus* of the Stimulus-Function.

The experiment was divided into two parts. The first part consisted of a learning situation, during which the five "right" and five "wrong" symbols were presented to the subject. The second, was a testing situation, in which only the "right" material of the learning situation was presented with gradient variations of this material. This testing situation was divided into two parts. The first began with a presentation of "right" symbols followed by seven gradient variations of each (see Fig. 2). In the second the same materials were presented but in exactly the reverse order, e. g., the most extreme variations of the "right" symbols were presented first and gradually varied back to the originals.

The learning series symbols were presented in the following chance order: 1, 3, 4, 2, 5, 3, 4, 5, 1, 2, 3, 4, 5, 1, 4, 2, 1, 5, 2, 3, 5, 2, 1, 4, 3, 2, 1, 4, 3, 5, 2, 1, 2, 4, 5, 3, 1, 4, 3, 5. Italicised numbers indicate "wrong" symbols. The gradient, but chance, order of the test series of symbols was as follows:

0	1	2	3
4, 1, 5, 2, 3	1, 4, 2, 5, 3	2, 5, 1, 3, 4	2, 3, 1, 5, 4
4	5	6	7
3, 1, 4, 2, 5	2, 4, 1, 3, 5	2, 1, 4, 3, 5	2, 1, 3, 4, 5

Digits above the bar are variation numbers and those below are symbol numbers. The symbols were drawn in black india ink on a belt of kymograph paper and each occupied a 24 by 29.5 mm. field.