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An experimental test of the Lashley hypothesis of selective attention and its relationship to the continuity-discontinuity issue in discrimination learning

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AN EXPERIMENTAL TEST OF THE LASHLEY HYPOTHESIS OF SELECTIVE
ATTENTION AND ITS RELATIONSHIP TO THE CONTINUITY-DISCONTINUITY
ISSUE IN DISCRIMINATION LEARNING.

Submitted by

Eugene H. Johns^{Hoover}

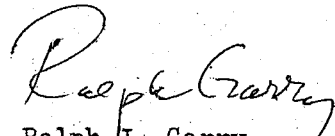
(B. A., Johnson C. Smith University, 1942)

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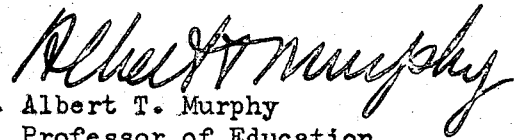
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First Reader:


Dr. Ralph J. Garry
Professor of Education

Second Reader:


Dr. Albert T. Murphy
Professor of Education

Third Reader:

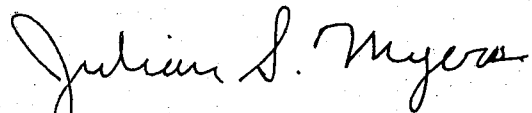

Dr. Julian S. Myers
Associate Professor of Education

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CHAPTER I

"No one can understand nature fully nor miss it wholly; but as each contributes his part there arises a structure that has a certain grandeur."

Aristotle

Introduction

Paradoxical as it may appear, the very factor that rendered other scientists and philosophers prone to view the young science of psychology with skepticism, has also injected vitality and stimulated its rapid and tremendous growth. Resultant from the wide and diversified application of the total field of psychology, the early developmental years were beset with the creation or founding of many "schools", each claiming to have chosen the only valid approach to the study of human behavior, the method sine qua non. The intense "warring" of these schools invariably gave rise to the belief that the science of psychology was an uncertain one unlikely ever to achieve the kind of unity or solidity so essential to acceptance by the society of sciences.

From these schools, such as Gestalt Psychology, Functionalism, Behaviorism, etc., has come a plethora of research unequalled perhaps by any science in a comparable period. Adherents of each group, while observing different aspects of behavior and applying different methods of study, shared one primary objective--the progress and growth of psychology. In time this affinity of purpose has rendered

possible the near elimination of the need for "schools" as well as a great stride in the direction of unifying the science.

Perhaps the most striking illustration of the gradual maturation of psychology into the full status of a science can be seen by an appraisal of the divergent and controversial views held by learning theorists. Slowly but steadily we find theorists coming closer together regarding points of difference and it would appear reasonable to envision within the foreseeable future the emergence of a single unified theory of learning. Future texts on learning theory will deal not so much with specific theories but with differential methods for observing learning phenomena.

The Major Differentiating Features of S-R and S-S Learning Theories

While recognizing the fact that there presently exists five major theories of learning, it is felt that for the purpose of considering the controversial issues from a theoretical rather than a methodological basis, all can be subsumed under either a stimulus-response or a sign-significate category.

Osgood^{1/} has listed the following as the most significant issues of controversy among contemporary learning theorists: 1. The necessity of reinforcement for learning. 2. The nature of secondary reinforcement. 3. Is there more than one type of learning? 4. The nature of

1/C. E. Osgood, Method and Theory in Experimental Psychology, Oxford University Press, New York, 1953, pp. 450-451

discrimination learning. These problems have arisen as a result of the divergent positions taken by Hull and his followers, which we are considering under the Stimulus-Response group (S-R) and the Sign-Significate (S-S) adherents led by Tolman. Inasmuch as we are concerned primarily with the specific nature of discrimination function in this investigation, only the features of the Hull and Tolman systems pertinent to this problem will be described.

The Mathematico-deductive system devised by Hull in 1929 is oftentimes spoken of as the Reinforcement Theory and would appear to originate from the older trial-and-error theory of Thorndike as well as the conditioned response views held by J. B. Watson.

Hull's major assumption is that reinforcement is a conditio sine qua non; that is, learning occurs whenever a response is closely followed by reinforcement or diminution of need. This learning is in the form of conditioning, successive reinforcements summing until habit-strength reaches a maximum performance level. Hull's^{1/} fourth postulate is the one with which we will be most concerned in this study. He states this as follows:

"Whenever an effector activity and a receptor activity occur in close temporal contiguity, and this is closely associated with the diminution of a need or with a stimulus which has been

^{1/}C. L. Hull, Principles of Behavior, Appleton-Century Press, New York, 1943, p. 178.

closely and consistently associated with the diminution of a need, there will result an increment to a tendency for that afferent impulse on later occasions to evoke that reaction. The increments from successive reinforcements summate in a manner which yields a combined habit strength which is a simple positive growth function of the number of reinforcements. The upper limit of this curve of learning is the product of (1) a positive growth function of the magnitude of need reduction which is involved in primary or which is associated with secondary reinforcement; (2) a negative function of the delay in reinforcement; and (3) a negative growth function of the degree of a synchronism of S and R when both are of brief duration, or (3b), in case the action of S is prolonged so as to overlap the beginning of R, a negative growth function of the duration of the continuous action of S on the receptor when R begins."

Despite numerous investigations by Tolman and his followers, very little akin to a formal system has been established. As the "leader" of the group we are calling sign-significate theorists, Tolman disagrees with Hull as to what the organism learns as well as the manner in which this learning occurs. He makes the following contrast of his view to that of the S-R group:^{1/}

"We believe that in the course of learning something like a field map of the environment gets established in the rat's brain. We agree with the other school that the rat in running a maze is exposed to stimuli and is finally led as a result of these stimuli to the responses which actually occur. We feel, however, that the intervening brain processes are more complicated, more patterned and often, pragmatically speaking, more autonomous than do the stimulus-response psychologists. Although we admit that the rat is bombarded by stimuli, we hold that his nervous system is surprisingly selective as to which of these stimuli it will let in at any given moment.

Secondly, we assert that the central office itself is far more like a map control room than it is like an old-fashioned telephone exchange. The stimuli, which are allowed in, are not

^{1/}E. C. Tolman, "Cognitive Maps in Rats and Men," Psychological Review (1955), pp. 191-192

connected by just simple one-to-one switches to the outgoing responses. Rather, the incoming impulses are usually worked over and elaborated in the central control room into a tentative, cognitive-like map of the environment. And it is this tentative map, indicating routes and paths and environmental relationships, which will finally determine what responses, if any, the animal will finally release."

It would appear perfectly clear that Tolman views learning not in the sense of a response to stimuli but rather to its meaning. We recall that Hull regards the diminution of need or drive reduction as essential to learning. Tolman in emphasizing the difference between learning and performance feels that contiguity is sufficient for learning and that reinforcement in the sense of reward only confirms learning. It seems obvious that Tolman believes that subjects acquire "cognitions" if you will, even though non liquet, performancewise.

The Continuity-Discontinuity Issue

Basic to the reinforcement theory is the assumption that discrimination learning is continuous, i.e., there are cumulative effects of training from its beginning until maximum habit strength is achieved. As regards this position, Spence ^{1/} states that discrimination learning is a

"...cumulative process of building up the excitatory tendency or association between the positive stimulus cue and the response of approaching it, as compared with the excitatory tendency of the negative stimulus cue, which receives only no-reinforcement, to evoke the response of approaching it. This

1/K. W. Spence, "The Nature of Discrimination Learning in Animals," Psychological Review (1936), 43:427-449.

process continues until the difference between the excitatory strengths of the two stimulus cues is sufficiently great to overshadow always any difference in excitatory strength as may exist between other aspects of the situation which happen on a particular trial to be allied in their response-evoking action with one or the other of the cue stimuli."

This viewpoint has been referred to by Krechevsky^{1/} and others as the "Continuity theory" as contrasted with Lashley's notion that all learning or "associations are formed very quickly and that both the practice preceding and the errors following are irrelevant to the actual formation of the association."

In stressing the discontinuous nature of discrimination learning, Lashley^{2/} has formulated the following postulates:

"1. When any complex of stimuli arouses nervous activity,certain elements or components become dominant for reaction while others become ineffective. This constitutes a 'set' to react to certain elements.

2. In any trial of a training series, only those components of the stimulating situation which are dominant....are associated. Other stimuli which excite the receptors are not associated because the animal is not set to react to them."

Experimentum Crucis.---Both groups of theorists suppose that a "presolution period" can be distinguished in animal learning, i.e., a period when the animal succeeds only by chance---in about 50 per cent of the trials. The solution period would be that learning

^{1/}I. Krechevsky, "I. A Note Concerning the Nature of Discrimination Learning in Animals," Psychological Review (1937), 44:97-103.

^{2/}K. S. Lashley, "Nervous Mechanisms in Learning," Foundations of Experimental Psychology, Clark University Press, New York, (1942), 26:241-265.

occurring from the 50 per cent to the 100 per cent level. They disagree, however, as to the nature of learning during these two periods. The continuity group feels that the correct solution or association is being "stamped in" from the time the first correct response is made. According to Lashley, no relevant learning occurs during the pre-solution period.

Reversal of Cues.—Spence^{1/} has stressed the fact that a crucial test of the validity of a non-continuity theory would be to reverse the values of the cue stimuli, that is, if "the positive stimulus is made negative and vice versa before the animal begins to show any learning whatever, it should not necessarily make for slower learning of the reversed problem, for according to this theory the animal selects and concentrates, in turn, on certain aspects of the experimental situation as offering possibilities of providing a solution and does not react to the real cue aspect until just at or just preceding the time of solution."

McCulloch and Pratt^{2/} in an experiment designed to test Lashley's notion found that rewarding the "wrong response" during the pre-solution period retarded later learning of the correct response in a string pulling problem. Rats given pre-solution training in

1/Op. cit., pp. 427-449.

2/T. L. McCulloch and J. C. Pratt, "A Study of the Pre-Solution Period in Weight Discrimination by White Rats," Journal of Comparative Psychology (1934), 18:271-290

which the lighter tray was baited with food were more handicapped in learning to pull in the heavier tray than were rats not subjected to such a reversal of correct cues. Different groups were subjected to different amounts of "wrong training" in the pre-solution period with a result that was reflected in error scores during the solution period. The number of errors during the solution stage of learning was roughly proportional to the number of errors made in the pre-solution period. These investigators interpreted their results as demonstrative of a "cumulative effect of training which is roughly proportional to the number of errors made."

Consistent with Spence's suggestion, Krechevsky^{1/} trained three groups of rats to differentiate a pattern comprising rows of small black squares from a pattern comprising columns of similar black squares. Rats in Group I received reinforcement only when responding with a jumping response to A. Group II received reinforcement of B for twenty trials then reinforcement of A until discrimination was learned. Group III received reinforcement of B for forty trials, followed by reinforcement of A. Consistent with a continuity position, Groups II and III should have been retarded as a result of early reinforcement of the incorrect stimulus pattern, and according to the non-continuity position, learning should have been equal for all three groups.

There were no greater trial-and-error scores made by Group II

^{1/}I. Krechevsky, "A Study of the Continuity of the Problem Solving Process," Psychological Review (1938), 45:107-134.

as compared with Group I (the control group). This would seem to be consistent with the non-continuity position. However, Spence feels that twenty trials is perhaps not adequate to cause the rat to commence responding to the experimental pattern aspects. He states that in experimental designs utilizing the jumping apparatus, a certain amount of training is essential to "make the appropriate receptor-orienting acts....that lead to reception of the critical stimulus patterns." The results of Group III did not fit in with the non-continuity position but rather tend to favor the continuity notion. The animals in this group which required or involved forty instead of twenty trials did make significantly more errors than the control group. Now, in this instance, Krechevsky levels an opinion converse to that of Spence: that is, forty trials would appear to be too much--they produce learning beyond the pre-solution period and as a consequence yield some oriented responses that transfer negatively when the habit is reversed.

Blum and Blum^{1/} in introducing an interpretation of Krechevsky's results state:

"Acuity decreases as distance from the fixation point is increased, so here it is surely possible that the accuracy of detail vision might be sufficiently reduced so that the differences of two patterns on the retina might not be much above threshold value. To carry our argument a step further, the great similarity of the retinal patterns causes the occurrence of much generalization from one card to the other. The more generalization there is between the discriminanda, the closer together are the

^{1/}R. A. Blum and J. S. Blum, "Factual Issues in the 'Continuity' controversy," Psychological Review (1949), 56:33-50.

stimulus compounds of which they are a part on the afferent generalization continuum. Thus there may be less habit strength to overcome by a certain number of trials of reversed pretraining on Krechevsky's problem than would be the case with an easier task.

Heretofore we have been contrasting Krechevsky's experimental conditions in general terms with those of other experimenters. Now let us consider the differential treatment of his three groups. The groups with habit strength to the stimulus which is incorrect after the reversal will, we assume, express this increased response tendency by a greater strength of jump, a shorter latency, more repetitive errors or correction trials, etc., in the early part of the test training than a group without such habit strength. A harder jump would mean more punishment per trial than the controls received, while a shorter latency or more repetitive errors would cause the incorrect responses to come at shorter intervals. Both these factors, as we have pointed out, tend to produce a more rapid reduction in positive response tendency. This increased might, in a group with a small amount of differential habit strength such as Krechevsky's Group II, more than compensate for the slightly greater habit strength it has to overcome than the controls. Group III has an even more rapid rate than Group II, but it may be past the optimum range because its differential habit strength had, by the time of reversal, become too large."

The above interpretation may serve to point out some of the inherent difficulties in this type of experiment. Ehrenfreud^{1/} in reviewing the continuity versus non-continuity issue postulated two criteria which must be met in order for a decision to be made:

1. assurance that the rat is receiving differential stimulation at the moment of response, and 2. statistical evidence that the cue values are actually reversed during the pre-solution period.

Now Krechevsky has emphasized the notion that animals do not learn anything about relevant stimuli while position habits are still

1/D. Ehrenfreund, "An Experimental Test of the Continuity Theory and Discrimination with Pattern Vision," *Journal of Comparative Physiological Psychology* (1948), 41:408-422.

present. Spence^{1/} in an experiment designed to test this notion administered differential reinforcement during the pre-solution period to rats that had previously fixated a position habit. After establishing a position habit in both an experimental and control group without the presence of black or white stimuli, the experimental group was reinforced fifty percent of the time each, black and white stimuli. The position habit was then eliminated and training commenced. Inasmuch as the results indicated a slower rate of learning for the experimental group following reversal than that of the control group, it would seem reasonable to suppose that associations were being formed with the to-be-discriminated or relevant stimuli even when the position habits or spatial hypotheses are present. Hence, this experiment would seem to support the continuity position.

Ehrenfreund^{2/} utilizing the Lashley jumping apparatus with upright and inverted triangles as relevant cues also obtained results similar to those reported only in those experimental conditions meeting the two criteria mentioned previously.

Irrelevant or Modified Cues.---In a paper primarily concerned with the present controversy, Lashley^{3/} reported an experiment in

^{1/}K. W. Spence, "An Experimental Test of the Continuity and Non-Continuity Theories of Discrimination Learning," Journal of Experimental Psychology (1945), 35:253-266.

^{2/}Ehrenfreund, op. cit., pp. 408-422.

^{3/}K. S. Lashley, "An Examination of the 'Continuity Theory' as Applied to Discriminative Learning," Journal of General Psychology (1942), 26:241-265.

which the essential change in experimental technique was a modification of cues in lieu of the above described reversal method. He states that:

"if the animals are given a set to react to one aspect of a stimulus situation, large amounts of training do not establish association with other aspects, so long as the original set remains effective for reaching the food."

In his experiment, Lashley trained four rats to discriminate between two circles differing in size. Hence a set for responding to size was established. After a criterion of twenty successful correct responses had been reached, the dimension shape was introduced. A large triangle was substituted for the larger circle. All the animals now chose the triangle in all the test trials. The triangle was made positive and the small circle negative and the animals were "overtrained" on the discrimination (two hundred trials). This training was introduced primarily to test the continuity position which implies that "all stimuli which are exciting receptors during a reaction are associated with that reaction." Hence, if the rats were responding to shape while responding to size also, they should show the beneficial effects of prior training when given only pattern discriminations as opposed to a group of animals not having received this earlier training. Lashley eliminated the size dimension and tested the rats with a triangle and a circle of the same size. After twenty trials, no preference for either figure was evident. Lashley feels that this and other similar experiments "flatly contradict the fundamental proposition of the conditioned-reflex theory of discrimination learning."

Blum and Blum^{1/} have described an experiment similar to that of Lashley except that instead of substituting only a large triangle for the large circle, they substituted also a small inverted triangle for the small circle. Their final test, then was an opposition of two inverted triangles of equal size. The original differentiation (large versus small circle) was established by five rats in an average of ninety six trials with an average error score of fifteen. In ten critical trials (inverted small triangle versus large triangle) animals A, B, and C selected the large triangle every time. Rat D selected it seven times, and rat E five times. After retraining on D and E (original circles,) these also made a perfect shift to the large triangle. In two hundred further trials, with the large erect triangle positive, the error score average was 0.6. In twenty subsequent critical trials (erect and inverted triangles of equal area, but intermediate in size between the original large and small figures) A, B, C, and D chose the large erect triangle twenty times and E nineteen times. The investigators state that "Our rats had evidently learned to discriminate the forms, despite a set presumable to size."

Discrimination After Simultaneous and Successive Training.--

According to Lashley, there should be no measurable generalization among stimuli when original training is restricted to a single stimulus,

^{1/}R. A. Blum and J. S. Blum, "Factual Issues in the 'Continuity' Controversy" Psychological Review (1949), 56:33-50.

Lashley and Wade^{1/} designed an experiment to test this contention. In this investigation only one of the stimuli was reversed in value during later training, and for the other stimulus another pattern substituted. Under the condition of training on a single stimulus, it was found that later reversal of sign value actually facilitated rather than hindered learning. Similar results were reported in ten experiments reviewed by these authors. They claim that such results are highly favorable to the non-continuity theory for, if learning were a process of accumulating negative or positive excitatory tendencies, the early negative training should have been disadvantageous in later learning with the previously negative stimulus now positive. The improved performance, however, would not appear explainable within the structure of either theory.

Grice^{2/}, critical of Lashley and Wade's study, repeated the experiment with several modifications. He claimed that an experiment utilizing the jumping apparatus is very punishing for the animal inasmuch as the rat constantly bumps its nose in making the jumps and this fact complicates the problem in such a manner as to possibly obscure the continuity issue. Grice trained his rats without punishment. Group I comprised of ten rats made two hundred reinforced responses to a single

1/K. S. Lashley and M. Wade, "The Pavlovian Theory of Generalization,"
Psychological Review (1946), 53:72-87

2/G. R. Grice, "The Effect of Differential Training to Single Stimuli
upon the Acquisition of a Six Discrimination Habit," American Psychologists
(1948), 3:242.

8-cm. white circle and Group II also comprised of ten animals made two hundred reinforced responses to a single 5-cm. white circle. Later training consisted in establishing a preference for the larger of the circles by both groups. His results in contrast to those of Lashley and Wade seemed to support the continuity position as much as the animals in Group I learned more efficiently than the second group. Grice gives the following interpretation of his findings:

"It is thus apparent that whether or not reversal cues hinders, facilitates, or has no influence on learning depends upon the particular experimental conditions used. Among the important factors obscuring the issue are differences in massing or distribution of trials, punishing and rewarding features of the experimental design, use of correction or non-correction technique, and the obviousness (to the animal) of the stimuli placed before it."

Summary

It would appear from the above review of many of the most pertinent studies on this controversial issue, that the evidence tends to favor a continuity position and hence, indirectly, Hull's reinforcement theory. However, as Blum and Blum^{1/} have pointed out, many of the experimental designs though rendering valuable information concerning the issue have to be considered indecisive in view of an assortment of weaknesses. Many theorists from both sides are beginning to take an eclectic view of the issue, i.e., consideration of the virtues in both

^{1/}Blum and Blum, op. cit., pp. 33-50.

the continuity and non-continuity positions. A striking example of this flexibility of thinking is evidenced by Leeper,^{1/} a follower of Tolman. An analysis of the research on this problem has led him to state:

"(Learning)....depends considerably on central processes of set, perceptual organization, etc., as the non-continuity view has proposed. But it also seems true that these processes in turn depend on gradual, cumulative effects to a considerable degree, as the continuity view has maintained."

Perhaps the most comprehensive appraisal of the status of the problem has been described by Osgood^{2/}. He lists the various facets of the Lashley position that have not withstood the rigor of experimentation. Osgood states:

"a. The notion that only those cues selectively attended by the subject can become associated with differential reactions is not substantiated in most 'reversal of cues' data or in the 'irrelevant cues' data, excepting Lashley's own rather casually reported findings. b. The same conclusion applies to discrimination after training on a single stimulus. c. Contrary to Lashley's contention, generalization has been shown to occur in training to respond to a single stimulus. And d. The notion that generalization and discrimination require active comparison of stimuli by the subject--and hence that successive discrimination should be more difficult than simultaneous discrimination--has not been upheld."

^{1/}R. Leeper, "The Continuity, Non-Continuity Issue in Learning--An Appraisal and a Reformulation," American Psychologist (1947), 2:316-317.

^{2/}C. E. Osgood, Method and Theory in Experimental Psychology, Oxford University Press, New York, 1953, pp. 450-451.

CHAPTER II

THE PROBLEM

"....a general method in which all truths of reason would be reduced to a kind of calculation. At the same time this would be a sort of universal language script, but definitely different from those projected hitherto; for the symbols and even the words in it would direct the reason; and errors, except those of fact would be mere mistakes in calculation."

Liebnitz

General Observations

Lashley, in reporting a relational type theory of discrimination learning patterned along the lines of Gestalt psychology, presents the notion that the subject does not form isolated stimulus-response associations with specific stimulus elements but learns to react to a relation between stimuli. This type of learning consists in perceiving relations in a manner that governs behavior. This view is very similar to what Krechevsky has called the formation of "hypotheses." Lashley's^{1/} position is most clearly stated in the following postulates:

"1. The 'dimensions' of a stimulus series are determined by comparison of two or more stimuli and don't exist for the organism until established by differential training. 2. Differentiation of conditioned reflexes involves the re-direction of attention to new aspects of the stimuli and the formation of new associations with these...."

This is tantamount to saying that there is an arousal of a set to react to certain elements of a given stimulus situation.

^{1/}K. S. Lashley, "An Examination of the Continuity Theory as Applied to Discriminative Learning," Journal of General Psychology (1942), 26:241-265.

The Lashley position is in direct opposition to the theory formulated by Hull^{1/} and later refined by Spence,^{2/} who adopt the view that all stimuli, those with both excitatory and inhibitory tendencies become associated with the response; and that these tendencies summate algebraically on the stimulus continuum to yield the effective reaction potential, i.e., learning is a continuous process.

The problem of selective attention in discrimination learning is significant and vital to the non-continuity versus non-continuity issue; for according to the non-continuity view, it is implied that during the pre-solution period in discrimination learning, there is no learning relevant to the discrimination problem, i.e., the subject begins to differentiate by selectively attending to the relevant cues only. Hence, proponents of this position maintain that discrimination learning is not a continuous process.

The question of why subjects, and particularly human subjects, evince differential learning efficiency for one cue over against a second cue can be answered in terms of stimulus characteristics. The "attention getting value" of a cue stimulus may be due to several characteristics, such as intensity, quality or the like. A second factor quite pertinent to selective association is that of prior

^{1/}C. L. Hull, Principles of Behavior, Appleton-Century, New York, 1943, p. 383.

^{2/}K. W. Spence, "The Nature of Discrimination Learning in Animals," Psychological Review (1936), 43:427-449.

experience with a given stimulus or at least with a similar cue. Most of the more recent studies utilizing humans as subjects have relegated prior experience with a stimulus to a major role in their experimental designs. Osgood^{1/} has pointed out that adequate experimental designs of the Lashley hypothesis of selective attention

- "a. provide the subject experience with one set of cues,
- b. give discrimination training in which this and another set are equally relevant, and c. test for dominance of the two sets of cues in determining subsequent discriminatory responses."

A series of two experiments by Lawrence,^{2/ 3/} would appear to meet the criteria listed above and inasmuch as many of the more recent designs utilizing human subjects have employed various aspects of this experimental design in exploring the role of selective attention in discrimination learning, it is felt that a description of one of these experiments might be illuminating. Lawrence feels that the results of his two experiments utilizing rats as subjects throws some light on the role or significance of the mediation and association variables as they relate to the stimulus situation and the instrumental response. His major hypothesis was that

1/C. E. Osgood, Method and Theory in Experimental Psychology, Oxford University Press, New York, 1953, pp. 450-451.

2/D. H. Lawrence, "Acquired Distinctiveness of Cues: I. Transfer Between Discriminations on the Bias of Familiarity with the Stimulus," Journal of Experimental Psychology (1949), 39:770-784.

3/D. H. Lawrence, "Acquired Distinctiveness of Cues: II. Selective Association in a Constant Stimulus Situation," Journal of Experimental Psychology (1950), 40:175-188.

"in learning instrumental responses in a previous discrimination situation, the relevant cues also become associated with mediating reactions which serve to make those cues more distinctive and hence facilitate any subsequent discriminations in which these cues may be involved."

Using two groups of twenty animals each, Lawrence trained one group on a successive discrimination to respond to a black-white stimulus (a two-compartment discrimination box) and to ignore the presence or absence of stiff wire chains installed at the compartment entrances. A second group of animals was similarly trained on the converse habit. Both groups were then trained on a simultaneous discrimination in which the choice-reaction could be made on the basis of either one or both cues, i.e., both cues were equally relevant. Three tests were then administered to all animals to determine the dominance of the two cue conditions. The tests of dominance employed were:

1. Opposition of cues.-- If the animal had been responding to black chains as positive and white-no-chains as negative, he was now given a choice of black-no-chains and white chains, i.e., the test situation involved a combination of the positive aspect of the preferred cue with the negative aspect of the non-preferred cue and conversely.

2. Relearning on single cues.-- This test consisted in retraining half the animals of each group with only one of the two sets of cues present. Upon completion of this training, the animals were retrained on the other cue.

3. Reversal of learning to single cues.-- To render possible further observation of the relative dominance of the preferred and non-preferred cues, the animals were made to relearn the discrimination

on each cue separately but with the positive and negative aspects of these cues reversed.

Lawrence^{1/} feels that the results of the above experiment support his underlying hypothesis since the facilitative effect of the preferred cue was maintained throughout all three tests. He further interprets the findings in terms of a two-stage postulation of discrimination learning. He says,

"The first stage of such learning was postulated to be the establishment of a mediating process that functionally altered the discriminability of the relevant cues thus making them more distinctive. The second stage consisted of the establishment of an association between the more distinctive stimulus pattern and the instrumental responses. The mediating process was assumed to be set up as the result of previous training on these cues and to transfer to situations. As a consequence, the learning of new instrumental responses would be facilitated."

Most learning theorists agree that mediating processes are significant and frequently vital to discrimination learning. That is, both adherents to the continuity as well as the non-continuity positions accept the fact that certain stimulus aspects are prepotent in determining reactions. The point of disagreement would appear to be a steadfast refusal of many members of both groups to accept a mediational hypothesis similar to that suggested by Lawrence^{2/ 3/} resultant from his two studies.

1/Op. Cit., pp. 175-188

2/D. H. Lawrence, "Acquired Distinctiveness of Cues: I. Transfer Between Discriminations on the Bias of Familiarity with the Stimulus," Journal of Experimental Psychology (1949), 39:770-784.

3/D. H. Lawrence, "Acquired Distinctiveness of Cues: II. Selective Association in a Constant Stimulus Situation," Journal of Experimental Psychology (1950), 40:175-188.

On the one hand, continuity theorists insist that all aspects of the stimulus situation become equally associated with the instrumental behavior, except for relative difficulties. While on the other hand, supporters of the non-continuity viewpoint feel that one and only one of the stimulus aspects becomes associated with the instrumental behavior.

Lawrence^{1/} has offered a formulation mediating these two positions. He believes, that,

"the degree to which the various aspects become associated with the response is partially determined by the previous experience of the subject with those aspects, but that this is a relative rather than an all-or-none affair."

His formulation is not contrary to the continuity position for he makes the assumption that the changes in the mediating process are gradual and continuous.

The present writer is of the opinion that findings similar to those obtained by Lawrence employing a similar paradigm can be obtained with human subjects. A major criticism of the Lawrence experiments, however, is his failure to make explicit the nature of the learning consisting in a tendency on the part of the animals to decrease attention to the irrelevant stimuli, i.e., this learning not to attend to the irrelevant stimuli. Hammer,^{2/} in an attempt to determine whether the subject learns not to attend to the irrelevant stimuli in discrimination learning, although the results between an experimental and control group

1/Op. cit., pp. 175-188

2/M. Hammer, "The Role of Irrelevant Stimuli in Human Discrimination Learning," Journal of Experimental Psychology (1955), 50:47-50.

were not significant, suggests that where location is not a distinguishing variable, responses are not associated with the irrelevant elements.

STATEMENT AND DISCUSSION OF THE PROBLEM

To observe the role of selective attention in human learning when the characteristics of the stimulus-response situation are manipulated.

To obtain information on the nature of discrimination learning relative to the continuity versus non-continuity issue.

Closely related to the problem of the nature of the discrimination process are the findings reported by Kurtz^{1/} who made a comparison of the discriminability of pairs of stimuli following three levels of prior training or familiarization. Employing a transfer paradigm, he found that subjects successfully transferred a discrimination response only in those prior training conditions when the training stimuli were identical to the test stimuli and those consisting of test pairs that were not identical but differed by the same property. When a new stimulus was introduced that differed from the first in a different property, negative transfer occurred. Kurtz feels that these findings are in close agreement with those obtained by Lashley with rats although the paradigms differed in that the latter employed the same overt responses during original training. Kurtz has interpreted his findings in the light of the Miller and Dollard^{2/} Observing Response formulation of discrimination

1/K. H. Kurtz, "Discrimination of Complex Stimuli: The Relationship of Training and Test Stimuli in Transfer of Discrimination," Journal of Experimental Psychology (1955), 50:283-291.

2/N. E. Miller and J. Dollard, Social Learning and Imitation, Yale University Press, New Haven.

learning. He defines this construct in terms of its functional properties rather than the topographical characteristics stating, that

"when (any response) made to one or the other of a given pair of stimulus complexes which are different, consistently results in distinctive stimulation from those two stimulus complexes."

This is tantamount to saying that as a result of prior training the relevant cue increases in distinctiveness over against the irrelevant cue.

The following findings of Lawrence^{1/} would appear to be closely related to those of Kurtz:

"1. The opposition test indicated that the animals tended to choose on the basis of the cue they had been taught to respond to, the 'preferred' cue, rather than on the basis of the one they had been taught to ignore, the 'non-preferred' cue."

2. The relearning test indicated that relearning was faster on the preferred cue.

3. The reversal test indicated that the animals reversed the discrimination on the preferred cue more rapidly than they did on the non-preferred cue."

The results of the two Lawrence studies

"...indicate that the learning of new instrumental responses is faster on a familiar cue than it is on a non-familiar one; that the influence of this familiarity is not restricted to the initial stages of learning is far advanced; that it has a selective influence on which of the aspects of the relevant stimulus will become associated with the instrumental behavior; and that these results are obtainable on a variety of perceptually simple stimulus dimensions."

The Hypothesis

Lashley,^{2/} in advocating the non-continuous nature of discrimination

1/Ibib., pp. 175-188.

2/K. S. Lashley, "An Examination of the 'continuity theory' as Applied to Discriminative Learning," Journal of General Psychology (1942), 26:241-265.

learning states that

"...if the animals are given a set to react to one aspect of a stimulus situation, large amounts of training do not establish associations with other aspects...."

Furthermore, if familiarization training is restricted to a single stimulus situation, generalization should be minimal.

Findings by Kurtz,^{1/} Lashley,^{2/} and Lawrence,^{3/} indicate that when subjects are tested with stimuli either identical to that received in prior-training or differing by the same property, learning on these test stimuli is facilitated. On the other hand, if the test pairs are arranged to include both "familiar" and a novel stimulus, we would expect an increase in discrimination errors, if the non-continuity position is feasible.

Now if the above hypothesis is correct, it would seem reasonable to suppose that, a group of subjects given an equal amount of training on three classes of S-R items, each class varying in cue meaning as well as response property should show no decrement in discrimination learning as compared with a group having received training on a single stimulus situation. Furthermore, the Lashley viewpoint would predict a faster rate of learning by subjects on "familiar" pairs when given a test consisting of an equal number of "familiar" and novel stimulus pairs.

1/Op. cit., pp. 283-291.

2/Op. cit., pp. 241-265.

3/Ibib., pp. 175-188.

The present study will attempt to make a comparison of obtained findings with those of the Lawrence experiments. The underlying hypothesis to be tested is: As a result of prior training, a mediating process is established that functionally alters the discriminability of the relevant cues in such a manner that they become more distinctive and hence, facilitate the learning of a new response. This assumption can be tested if the experimental design is constructed so as to provide the subjects by prior training (a) experience with one set of cues, (b) give training in which this and a second set of cues are equally relevant, and (c) finally test for the dominance of these cues in subsequent discrimination responses.

Basic Assumptions.--

1. If subjects are tested with stimuli differing by the same property as that received in familiarization training, learning on these test stimuli will be facilitated.

2. If familiarization training is restricted to a single stimuli situation there will result a difference in the discrimination errors of this group and one trained by the simultaneous method.

3. The influence of familiarization training is not restricted to the initial stages of learning but tends to become more dominant in advanced and more complex tasks.

4. The rate of learning a reversed association is significantly dependent upon the strength of the original habit.

While non-continuity theorists agree that selective attention is prepotent in determining the rate and/or efficiency of discrimination

learning, i.e., the relationship between stimuli and responses are dependent upon mediating and association processes, it is felt that the present design will demonstrate that the role ascribed to these processes is not identical nor comparable in human subjects.

CHAPTER III

EXPERIMENTAL METHOD

"....So much of what we call science is guesswork. We may weigh, measure, or carry out precise tests of various kinds, but all, or most, of the important conclusions are guesswork; or to be more exact, intuitive deductions against a background of more precise knowledge."

Maurice Burton

Differential learning efficiency for one cue as opposed to a second cue can be attributed to two major factors; The characteristics or attributes of the stimulus such as intensity, quality, etc., and prior experience with a stimulus. Investigations by Kurtz, Lashley and Lawrence indicate that when subjects are tested with stimuli either identical to that received in prior-training or differing by the same property, learning on these test stimuli is facilitated. This is tantamount to saying that there is an arousal of a set to react to certain elements of a given stimulus situation.

The problem of selective attention--the fact that certain stimulus characteristics are prepotent in determining choice reactions in discrimination learning is significant to the continuity-discontinuity controversy. Stimulus-response theorists interpret discrimination learning as continuous, performance being a direct measure of habit strength. That is, an explanation of selective attention is to be made in terms of the establishment of a stronger association between the overt response and the familiar or "preferred" cue. On the other hand, the

discontinuity view as held by Lashley suggests that attention must be dissociated from the association process, for during the presolution period in discrimination learning there is no learning relevant to the discrimination.

The purpose of the present investigation was to experimentally test the validity of the Lashley formulation of selective attention; and to obtain, if possible, information as to the nature of discrimination learning relative to the continuity-discontinuity issue.

Training or familiarization procedures almost identical to those employed by Kurtz^{1/} were utilized in the present study. Two groups of subjects were each provided experience with one set of stimuli prior to the administration of test stimuli. A third group was provided experience with an equal number of stimulus pairs identical to those provided the first two groups; that is, the stimulus pairs represented half the total items of each of the lists administered to groups one and two. A fourth group of subjects received no prior-training. The tasks used for test purposes were paired-associate discrimination learning problems, each pair consisting of a stimulus figure and a response word. These test pairs, while not identical to those used in the training condition, differed by the same property. Actually the experiment was designed so that the single stimuli groups (I and II) would subsequently receive discrimination tests on familiar and novel stimuli. Hence, the third or successive stimuli group having been provided experience on both

^{1/}Kurtz, op. cit., pp. 283-91

sets of cues would receive discrimination tests consisting of only familiar stimuli.

Subjects.-- A total of 64 female students were selected from various undergraduate schools in Boston University and randomly assigned to the experimental groups. All were naive as to the purpose of the investigation. The subject population represents an age range of 18 to 23 years.

Instructions to the Subjects.-- "The tasks which you will be required to perform has no relationship whatsoever to personality or intelligence. We are interested primarily in how accurate you are in recalling the figures shown in association with a particular word. You will be shown a series of twelve (12) pairs of words and figures. The first time the list is shown, you are to try and learn as many of the pairs as possible. Do not try to learn the order in which the items appear. After the list has been presented once, it will be shown again; the same pairs but in different order. When you see the stimulus figure, reply with the word figure paired with it in the first list. If you are not certain of the correct response, guess at it. The experiment will be continued until you get the entire list correct once (or the appropriate portion of the list)." The subjects were given no additional information.

Stimulus Materials.--The stimulus items consisted of one-inch circles and squares and were varied as to degree and location of shading within each figure. The response words, both meaningful and non-sense, comprising each list are identical to those analyzed for degree

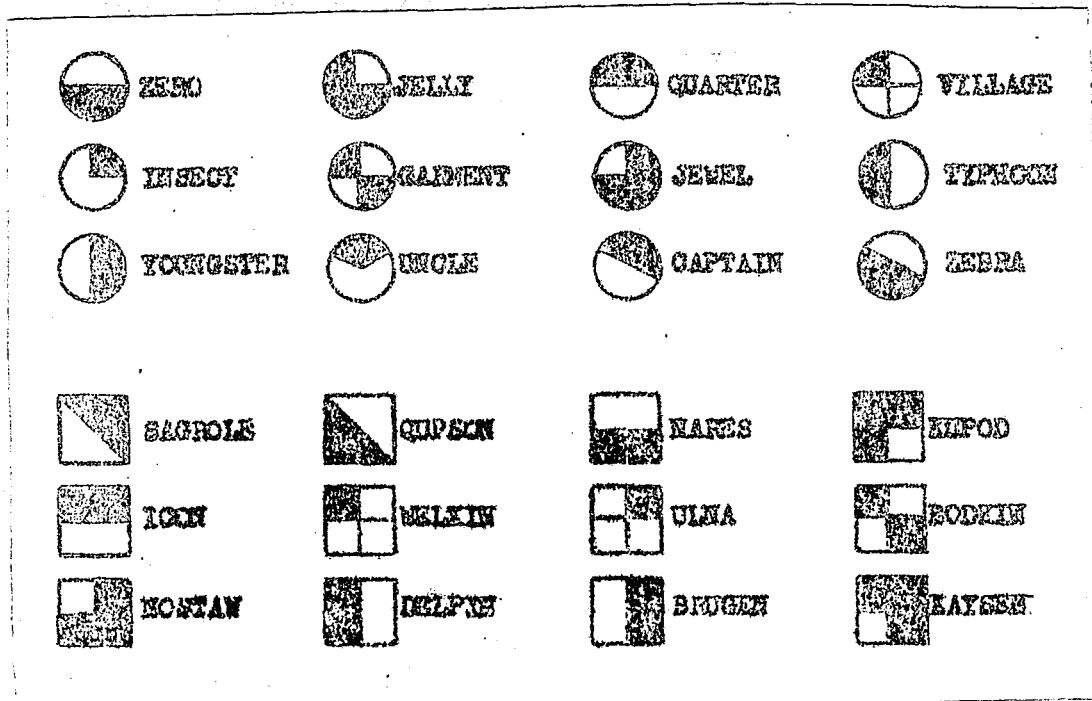


FIGURE 1. Familiarization Training S-R Items. Twelve of the above S-R pairs were selected for each of the familiarization conditions

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of meaningfulness by Noble.^{1/} Hence, each stimulus item consists of three dimensions: form, degree and location of shading. There were two degrees of meaningfulness manipulated as response items.

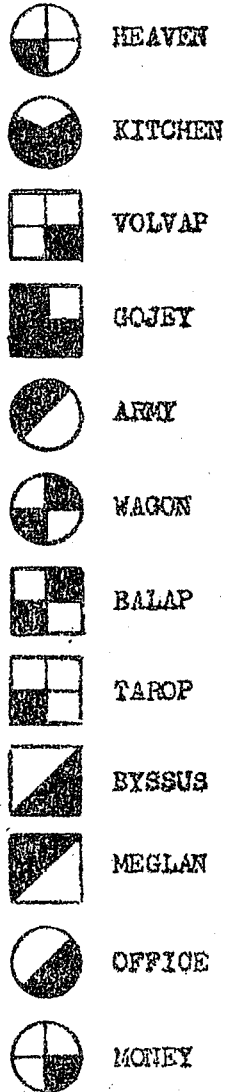
Training Stimuli.-- Materials for the training condition consisted of 3" x 5" index cards on each of which was a reproduction of a stimulus-response pair similar to those used in the test conditions (See Figure I).

Paired-Associate lists.-- Twelve pairs of stimulus-response items in each list were arranged on a paper tape for presentation in a memory apparatus. The tape for each list included ten different permutations of the twelve stimulus-response items. A given stimulus item was always paired with the same response item throughout all ten permutations of a given list. The response words were typed-written and all letters capitalized. The ten permutations in each tape were random in that no pair was immediately followed by any other pair more than once in the entire sequence.

Apparatus.-- The apparatus used in this study was a modified memory drum manufactured by the Stoelting Company. A larger reduction gear was affixed to the electric motor so as to cause the driving wheel to rotate once in three seconds. This apparatus is so designed that the subject could observe only one stimulus pair through a small adjustable aperture. The subject was seated facing the aperture of the apparatus just opposite the experimenter, but separated by a black screen.

1/C. E. Noble, "The Role of Stimulus Meaning (m) in Serial Verbal Learning," Journal of Experimental Psychology (1952). 43:437-446

Opposition of Cues Test



Reversal of Cues Test

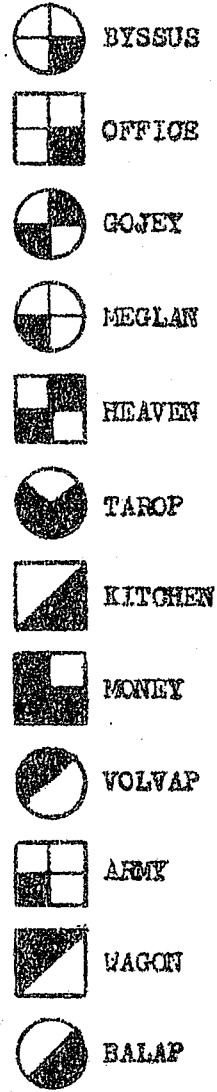


FIGURE 2. Tests for Dominance. Presentation of one permutation of the S-R pairs used in each of the tests for dominance. The stimulus figures and response words are identical for each test; but, in the Reversal Test, circle figures are paired with nonsense words and square figures with meaningful words.

EXPERIMENTAL PROCEDURE AND DESIGN

The total 64 subjects were divided into four major groups (A, B, C and D) of 16 each. Groups A, B and C were each provided familiarization training as follows:

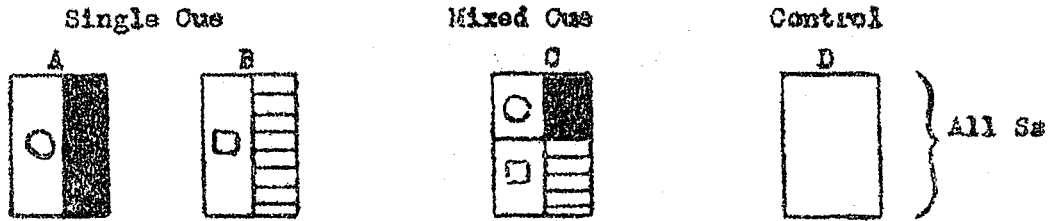
1. Group A - circle figures and meaningful words
2. Group B - square figures and nonsense words
3. Group C - circle figures and meaningful words; square figures and nonsense words.
4. Group D - no familiarization training (Control group).

This familiarization training consisted in presenting 12 cards as described in the section on materials to the subject one at a time. The stimulus-response pair on each card was presented for approximately one second, an interval of one second separating presentation of a second card. After all cards were presented to the subject, he was required to give the correct response item when shown the stimulus associate. After each trial run through the entire 12 cards, any card on which the subject made no error was removed; the remaining cards were reshuffled and again presented in the same manner. The procedure was repeated until the subject completed two successive errorless runs through all 12 cards.

Tests for Dominance.

Opposition of Cues test.--As a test for transfer effects, the entire group of subjects was required to learn a paired-associate list consisting of 12 pairs of S-R items including 6 pairs of circle figure-meaningful word items and 6 pairs of square figure-nonsense word items. Each

FAMILIARIZATION TRAINING



TESTS FOR DOMINANCE

Opposition of Cues Test



Reversal of Cues Test



FIGURE 3. Experimental Paradigm. Each large block represents a serial list consisting of 12-paired associate items. The blackened blocks and the striped blocks indicate meaningful words and nonsense words respectively. Example: The familiarization serial list for Group C consists of 6 circle figure-meaningful word pairs and 6 square figure-nonsense word pa

group was subdivided so that one half the subjects, eight in each subgroup, learned the paired-associate list to a 100% criterion of mastery, while the other half learned the list to a 50% criterion of mastery.

Reversal of Cues test.--The subjects of each group and subgroup were exposed to a second paired associate list in the same fashion as in the above test with the following exceptions: a) all subjects were required to learn the S-R items of this list to a 100% criterion of mastery, and b) the cue stimulus figure and the response word were now reversed; for example, if the subject had been responding to a circle figure-meaningful word relationship, he was now required to respond to the same figure with nonsense word items formerly associated with square figures.

Figure 2 shows the experimental treatment of subjects for both the familiarization and dominance test conditions.

CHAPTER FOUR

RESULTS

"Science is bound by the everlasting law of honor to face fearlessly every problem that can fairly be presented to it."

Lord Kelvin

The present investigation consisted essentially in providing the subjects with three types of familiarization training. The training was designed so that the subjects either received experience on only one class of S-R items, (a) circle-figures and meaningful words or (b) square-figures and nonsense words; Or were trained with two classes of S-R items, (c) a combination consisting of equal portions of the same items found in the lists a and b. During the familiarization training the subjects learned paired-associate items to the level of two consecutive errorless trials. These items were highly similar to those comprising the tests for dominance in that the same dimensions were varied. No record of the number of trials required to reach the 100% mastery level was kept inasmuch as the objective was merely to thoroughly familiarize the subject with a given class or classes of S-R items and thereby establish a "set" or "preference" to respond more accurately to those items in subsequent associations.

Tests for Dominance.--The total subject population regardless of the assigned group received identical tests for dominance which were administered immediately following the familiarization training

condition. The opposition of cues test consisted of a paired-associate list of 12 pairs, six pair of circle figure-meaningful word items and six pair of square figure-nonsense word items. The reversal of cues test administered immediately following completion of the opposition test consisted of the identical items found in the opposition test but with the cues reversed, i.e., circle figures were now paired with nonsense words, and square figures paired with meaningful words.

TABLE I
EXPERIMENTAL TREATMENT OF SUBJECTS

	A Circle Meaningful		B Square Nonsense		C Simultaneous or Mixed		D Control (No Training)	
Opposition of Cues test	100%	50%	100%	50%	100%	50%	100%	50%
	8 S's	8 S's	8 S's	8 S's	8 S's	8 S's	8 S's	8 S's
Reversal of Cues test	All Subjects		All Subjects		All Subjects		All Subjects	

Grouping.---The subjects were randomly assigned to the various groups and subgroups as represented in Table I (see also experimental paradigm). Each group or subgroup, designated in accordance with the type of familiarization training received, including the control group, has been further subdivided into a 100% and a 50% level of mastery group. A note of explanation is necessary here.

On both the opposition and reversal of cues tests, the 100% mastery group learned the respective lists to a criterion of one errorless trial. The 50% mastery group learned the opposition of cues list to the 50% level of mastery and the reversal of cues list to the 100% level. Hence, for the most part, the data for these two groups has been treated separately.

Scoring Criterion.—Discrimination learning on both the familiarization and dominance test conditions was measured by the recall method. For the subjects assigned to the 100% mastery group, it was required that the response word items learned in association with all 12 figures be recalled until a criterion of one errorless trial was reached. The second half of the subject population was required to learn the figure-word lists to the 50% level of mastery or until a criterion of 6 correct responses was attained on a given trial in the opposition of cues test. It may be well to note that for the 50% mastery group, no further exposure of the remaining items of a list was given after the subject achieved 6 correct responses on a trial. Cognizance is taken of the fact that there can be no statistical certainty as to the precise per cent level of mastery achieved beyond the 6 responses. For this reason, no comparisons of the opposition of cues data for the 100% and the 50% groups were made. It was felt, however, that the relative habit strengths of the two groups should differ to such

an extent as to render significant a comparison of their performance on the reversal of cues test.

While data was obtained on the number of trials required to reach the designated level of mastery, the statistical treatment or comparison of these trials offers little to an interpretation of performance, pooled or individual. At least this would seem to hold in an experimental design of this type utilizing the recall method of retention. The number of trials in most cases was roughly proportional to one another throughout the four experimental groups for each test for dominance. Hence, the complete analysis of this investigation is based, essentially, on the number of errors.

TABLE II

FOUR PART ANALYSIS OF VARIANCE OF THE ERROR SCORES
FOR ALL FOUR EXPERIMENTAL CONDITIONS

Source of Variation	Sum of Squares	df	Mean Square	F
Training	6,227.560	3	2,075.853	44.6
Dominance Tests	562.500	1	562.500	12.1
Interaction:				
Training X Tests	3,135.580	3	1,045.193	22.0
Within Groups	<u>2,605.860</u>	<u>56</u>	46.453	
Total	12,531.500	63		

The results of an analysis of variance of the error scores made by the subjects in the 100% level of mastery group represent

a division of the total sum of squares and degrees of freedom into four parts: (1) Differences between the four experimental treatments, or differential training groups; (2) Variation between opposition and reversal of cues tests; (3) Interaction between training and tests, and (4) the variation of subjects treated alike. This analysis is shown in Table II. It may be noted that the F values for the total training effects based upon 3 and 56 degrees of freedom, as well as the between dominance tests variation based upon 1 and 3 degrees of freedom, are well beyond the 5 per cent level of confidence. Hence, it would seem reasonable to suppose at this stage of the analysis, that there exists adequate similarity of differences between the means of the four training groups to account for an absence of interaction. This is further indicated in the lack of interaction between tests and training sums.

TABLE III

THE MEAN ERROR AND STANDARD DEVIATION SCORES
FOR THE FOUR EXPERIMENTAL GROUPS (100% Level)

	A		B		C		D	
	Circle		Square		Mixed		Control	
	Meaningful		Nonsense				(No Training)	
	M	SD	M	SD	M	SD	M	SD
Opposition of Cues	19.0	7.28	29.1	5.74	27.8	4.70	43.5	2.64
Reversal of Cues	15.4	6.08	27.1	9.27	39.5	6.85	45.2	10.81
Differences *	-3.6		-2.0		*11.7		*1.7	

*Reversal score greater than opposition score.

Opposition of Cues test.---The mean number of errors and standard deviation scores for each experimental condition and the mean differences are shown in Table III. It may be seen that Group A, i.e., the group receiving familiarization training on the circle figures and meaningful words is clearly superior in performance to all other experimental conditions on the opposition of cues test, particularly the control group D. The mean number of errors for all other groups is at least 10.0 points higher than that of group A. The experimental groups B and C also show lower mean error scores than those of the control group, the minimum error difference being 14.4 points. The mean difference of 1.3 points between the experimental groups B and C, in favor of the latter is not regarded as significant at this point.

Reversal of Cues Test.---The superiority in performance of group A over all other conditions is also apparent on this test, the minimum error difference showing a slight increase to 11.7. The mean number of errors for group B, which is slightly higher than the mean of group C on the opposition of cues test now shows an error score 12.4 points lower than group C. As in the previous test, the error scores of all experimental conditions are superior that is lower than those of the control group, D.

A comparison of the within group mean error scores shows that subjects in groups A and B learned to reverse the discrimination at a slightly faster rate than that attained on the opposition

of cues test. On the other hand, groups C and D show a slower reversal rate , particularly group C.

Comparison of the Significance and Differences
Between the Group Means

In order to more clearly understand and explain the differential effects of familiarization training on performance, the means of the four experimental groups have been combined and compared in the following ways:

1. Groups A, B, and C vs. D. Familiarization training vs. no training.
2. Groups A vs. B. Circle figure-meaningful word pairs vs. square figure-nonsense word pairs.
3. Groups A and B vs. C. Single training vs. simultaneous or mixed.

TABLE IV

A COMPARISON OF THE FAMILIARIZATION AND CONTROL GROUPS

	(A, B, and C) Familiarization Training	(D) Control	Difference
Opposition of Cues	25.3	43.5	18.2
Reversal of Cues	27.3	45.2	17.9

I. When subjects are tested with stimuli differing by the same property as that received in familiarization training, learning on these test stimuli is facilitated.

As evident in previous comparisons, the experimental groups A, B, and C, those receiving prior familiarization training, show a striking superiority over the control group D. As may be noted in Table IV, the difference between the combined means of groups A, B, C and D is 18.2. The t score for this comparison is 4.55 for 30 degrees of freedom. Hence, the probability of obtaining a value as large as this is therefore less than .01 under the hypothesis of random sampling from a common population.

When the training groups A, B, and C are compared with the control group D on the reversal test, performance similar to that obtained on the opposition of cues test is evident. The difference in the means of these two groups is 17.9. The t score for this difference is 2.52, 30 df, P less than .05. The combination of the means of these two groups on the reversal test reflects, however, a larger error score and a slightly smaller difference between the two groups.

TABLE V

A COMPARISON OF GROUPS TRAINED BY THE SINGLE STIMULI METHOD

	(A) Circle figure- Meaningful word pairs	(B) Square figure- Nonsense word pairs	Difference
Opposition of cues test	19.0	29.1	10.1
Reversal of Cues test	15.4	27.1	11.7

II. The degree of facilitation is dependent upon the type of familiarization training received.

a) If familiarization training is restricted to a single stimuli situation or class of S-R items, there will result a decrease in discrimination errors on subsequent tests. A second comparison was made of the significance and difference between the means of groups A and B (see Table V). It may be recalled that these two groups received prior familiarization training on only one class of S-R items. The essential difference between the training of these two groups is that group A was familiarized with circle-figures paired with meaningful words while group B received prior training consisting of square-figures paired with nonsense words. The mean difference for this comparison is 10.1 and yields a t score of 1.87 for 14 degrees of freedom, P is less than .1.

A comparison of the means of groups A and B on the reversal of cues test shows that both groups learned the reversed discrimination at a faster rate than on the opposition test when the pairs were merely opposed to one another. The difference between the two groups is increased somewhat though not significantly. The difference between the means yields a t score of 1.74, 14 df, P is less than .1.

The significance and difference of the above two groups (A,B)

involved training by the single stimuli method and the comparison is directed primarily toward the content or kind of discrimination material. The subjects of group C, which is being called the simultaneous or mixed group, however, received prior familiarization training on both classes of S-R items, i.e., an equal distribution of circle-figures paired with meaningful words and square-figures paired with nonsense words. Now when the mean of the single stimuli group is compared with that of the simultaneous or mixed group as represented in Table VI, a difference of 3.8 in favor of the former group is evident. The t score for this difference is .863, 22 df, P is greater than .5, suggesting significance not beyond the level of chance.

TABLE VI
 A COMPARISON OF TRAINING BY THE SINGLE STIMULI
 AND SIMULTANEOUS METHODS

	(A,B) Single Stimuli Method	(C) Simultaneous Method	Difference
Opposition of Cues test	24.0	27.8	3.8
Reversal of Cues test	21.2	39.5	18.3

The combined means of groups A and B as compared with that of group C provide the most striking contrast in results thusfar evident in the analysis. It may be noted that while the difference

between the means of these two groups is only 3.8 on the opposition test, it is 18.3 on the reversal test, an increase of 14.5 in the mean number of errors. The comparative analysis of these two groups becomes even more complex inasmuch as the combined groups A and B show a faster rate of learning on the reversal test while group C shows an increase of 11.7 in the mean number of errors. The difference between the means of these two groups on the reversal test would appear, however, significant--P is less than .02. These findings would imply that: III The influence of familiarization training is not restricted to the initial stages of learning but tends to facilitate the formation of more complex or advanced habits.

AN ANALYSIS OF PERFORMANCE OF THE 50% LEVEL OF MASTERY GROUPS

This group differs from the 100% level of mastery group in that the subject population in this case were required to learn the figure-word lists to only the 50% level of mastery or until a criterion of 6 correct responses were made on the opposition of cues test. The level of mastery on the reversal test, however, for this group was 100%. As mentioned earlier, cognizance is taken of the fact that there is no statistical certainty as to the precise level of mastery attained by this group on the opposition test inasmuch as no further responses were taken after the sixth correct response on a trial. For this reason, comparisons within groups between the two dominance tests as well as those between the

opposition test results of this and the 100% groups have not been made.

TABLE VII

THE MEAN ERROR AND STANDARD DEVIATION SCORES FOR
THE FOUR EXPERIMENTAL GROUPS (50% LEVEL)

	A		B		C		D	
	M	SD	M	SD	M	SD	M	SD
Opposition	12.5	3.16	20.2	3.87	15.1	7.55	25.1	8.24
Reversal	29.3	5.65	36.1	7.07	35.7	7.00	39.8	7.61

Results of the Opposition of Cues Test.---In Table VII are shown the mean error and standard deviation scores for each experimental group in the 50% level of mastery group. Similarly to the group just considered, the proficiency positions of the four major groups remains unchanged insofar as the mean error scores are concerned. As may be seen in the Table, the group receiving prior familiarization training, group A, also attains a 50% level of mastery in a minimum of 3.0 mean error points faster than the nearest group--group C, or that group receiving familiarization training of the mixed type. All groups show a faster rate of learning than the control group D.

When the mean error scores of the major groups are combined, a further comparison of the effects of training shows that groups receiving familiarization training (A, B, and C) are superior in performance to the control group D. The t score for this difference is 4.00 for 30 df with a probability of less than .01.

The difference between the means of groups A and B, those receiving prior training by the single stimuli method is 7.7 and yields a t score of 1.35, 14 df, P is less than .2.

The final comparison of the difference between the combined means involves the method of training, i.e., single stimuli method versus the simultaneous or mixed method. An extremely small difference exists between the means of groups A, B, and C. This difference is only 1.2 and is not regarded as significant beyond the level of chance. The t score for this difference is .661 for 14 df, with a probability of .6.

Results of the Reversal of Cues Test.---The mean and standard deviation scores indicate a superiority of group A over all other groups. However, the overall variance between groups on this test is quite small. This holds also for the standard deviation scores at least for groups B, C, and D.

A combination of the mean error scores of several groups would also appear to indicate very little variance in most cases. The difference between the means of groups A, B, C and the control group D is 6.1 which yields a t score of 1.68, 30 df, probability less than .1.

The combined groups A, and B show a superiority in performance over group C though the difference is only 3.0. It may be recalled that the difference is also small (1.2) on the opposition test although group A and B is inferior to group C. The t score for the

difference between these groups on the reversal test then is 3.0, t score of .769, 22 df, probability less than .5.

COMPARISON OF PERFORMANCE OF THE TWO MASTERY GROUPS
ON THE REVERSAL OF CUES TEST

The present experimental design is of such nature as to render possible a comparison of the mean error scores of the four major groups consistent to their relative habit strength. This is due to the fact that one half of the subjects learned the discrimination to perfect mastery on the opposition of cues test while the learning of the remaining subjects was held, numerically, at least, at the 50% level of mastery.

TABLE VII

COMPARISON OF THE MEAN ERROR SCORES OF THE
50% and 100% LEVEL OF MASTERY GROUPS
(REVERSAL OF CUES TEST)

	A	B	C	D	Group Mean
100% Level	15.4	27.1	39.5	45.2	31.8
50% Level	29.3	36.1	35.7	39.8	35.2
Difference	-13.9	-9.0	* 3.8	* 5.4	3.4

* 50% mastery group demonstrated faster learning.

IV. When the relative habit strength of two tasks is varied, it will be easier to reverse the stronger habits

a). Such facilitation, however, appears evident only

When the condition of familiarization training is restricted to a single stimuli situation.

When the subjects of both mastery levels received prior familiarization training they demonstrated a superior performance to that of the control group. On both mastery levels familiarization by the single method proved more beneficial for those subjects trained on circle figure-meaningful word pairs as opposed to those trained on the square figure-nonsense word pairs. However, the 100% level of mastery subjects in groups A and B show a significant superiority over subjects in the same groups on the 50% level.

Perhaps the most striking results are those obtained by a comparison of the mixed and control groups. It may be seen in Table VII that both groups C and D show a faster reversal rate by those subjects learning the discrimination on the opposition test to the 50% level of mastery.

CHAPTER V

Discussion

"No one can understand nature fully nor miss it wholly; but as each contributes his part there arises a structure that has a certain grandeur."

Aristotle

The prepotency of certain stimulus characteristics to determine choice reactions in discrimination learning may well represent one of the most critical aspects of Lashley's theory--that of selective attention. It may be recalled that he, greatly influenced by the Gestalt psychologists, takes the notion that learning is not a form of isolated response associations with specific stimulus elements, but rather a reaction between stimuli. It is apparent that Lashley favors a conceptual learning theory that would involve the dynamic perceptual organization of behavior in lieu of what many of his followers might call the "unitary" theory of the S-R psychologists represented by such stalwarts as Hull and Spence.

Lashley is very emphatic in pointing out that discrimination learning cannot occur except by comparison of two or more stimuli and is non-existent until established by differential training. He further feels that discrimination involves the manipulation or direction of attention to various aspects of other stimuli. This is tantamount to saying there is an arousal of a set to react to certain elements of a given stimulus situation. In other words, if a subject is trained to respond to a given cue, new associations will be more readily formed

when this cue is involved than in stimulus situations comprised of all novel stimuli.

The problem of selective attention is significant and vital to the continuity-discontinuity issue. It may be recalled that Hull's theory as refined by Spence takes the notion that all stimuli, those with both excitatory and inhibitory tendencies become associated with the response, these tendencies summing algebraically on the stimulus continuum to yield the effective reaction potential. On the other hand, the discontinuity theorists dissociate learning from performance and imply that during the presolution period in discrimination, there is no learning relevant to the discrimination. The activity during this period is comprised solely of the formation of irrelevant "hypotheses"; and it is only after these incorrect solutions are eliminated that the subject commences to learn the discrimination problem. The discrimination occurs by selectively attending to the relevant cues only.

It would appear that the assumption underlying the stimulus-response interpretation of selective attention is that there is established a stronger association between the overt response or performance and the preferred cue. Lawrence has pointed out, however, that such an assumption is justified only within the confines of a unitary conception of the relation between the stimulus and the instrumental response. This relationship then, would be entirely dependent upon the strength of the association established. Lawrence, while not rejecting the S-R interpretation in its entirety, suggests the necessity for postulating a two-stage process consisting of a mediational variable that

enhances the distinctiveness of the relevant cue, and an association variable to account for the strengthening of the association between the instrumental response and the enhanced cue.

Actually then, three views are offered to us as possible interpretations of the phenomena of selective attention as it affects the continuity-discontinuity issue. First we have the Lashley formulation which requires that the mediational process (attention, in Lashley's terms) be dissociated from the association process. Secondly, the strict stimulus-response theorists present an interpretation of the stimulus-response relationship as a continuous unit, performance being a direct measure of the strength of association. Finally, Lawrence postulates a third formulation which he feels, while analogous to Lashley's concept, is an extension of S-R concepts. This two-stage formulation as described above was felt necessary to account for the faster reversal rate of strong habits over against weaker ones. Lawrence has described this formulation as an "hypothesis of acquired distinctiveness of cues" and compares it with the discontinuity view as follows:

"The hypothesis of the acquired distinctiveness of cues and the non-continuity theories of learning differ as to the characteristics they ascribe to the mediating process. The latter tend to emphasize the all-or-none characteristic of shifts in attention during the presolution period of learning. The present formulation assumes that the changes in the mediating process are of a gradual and continuous nature. Both agree, however, that the end result of such modifications may be a qualitative change in the 'perceptual' characteristics of the situation. Because of this difference in emphasis, the two formulations tend to disagree also as to the extent that attention limits the association between various stimulus aspects and the instrumental behavior. The non-continuity theories tend to emphasize that only the aspect attended to becomes associated with the stimulus. The present formulation assumes that the relevant aspect of the stimulus becomes relatively more distinctive

than the other aspects; there is a reordering of the 'association values' of the various aspects but none is necessarily excluded from the association."¹/

The purpose of the present investigation was to experimentally test the validity of the Lashley formulation of selective attention in discrimination learning; and to obtain, if possible, information as to the nature of discrimination learning relative to the continuity-discontinuity issue. It was felt that an experimental design very similar to that constructed by Lawrence for use with animal subjects could be modified in such a way as to render possible the observation of the phenomena of selective attention in human subjects. It was suggested that while the relationship between stimuli and response may be dependent upon two variables, a mediating and association process, the present design would demonstrate that the role ascribed to these processes is not identical nor comparable in humans.

It should be remembered that this writer was not inclined to accept nor reject any of the views or interpretations of selective attention presented above. Instead, the primary aim of this study was to design and conduct an experiment, utilizing human subjects, methodologically similar enough to other studies as to render possible a logical comparison of the obtained results.

Inasmuch as the present investigation is essentially a modification of the Lawrence experiment, but utilizing humans as subjects, it

¹/D. H. Lawrence, "Acquired distinctiveness of cues: II. Selective association in a constant stimulus situation. Journal of Experimental Psychology, (1950), 40, 175-187.

would seem feasible to make a comparison of results in regard to the degree of consistency. There do exist, however, certain similar and differentiating features between the two designs which may be well worth noting. Both experimental designs are constructed so as to (a) provide the subjects by prior training, experience with one set of cues, (b) give training in which this and a second set of cues are equally relevant, and (c) finally test for the dominance of these cues in subsequent discrimination responses. The underlying assumption is that as a result of prior training, a "mediating process" is established that functionally alters the discriminability of the relevant cues in such a manner that they become more distinctive and hence, facilitate learning of a new response.

The present study divided the total subject population of 64 subjects into four main groups in accordance with the type of familiarization training received: (A and B), single stimuli groups in which the subjects received experience on only one class of stimuli items, Group A being trained on circle figures paired with meaningful words and group B, trained on square figures paired with nonsense words; (C), simultaneous or mixed group that was provided experience with both classes of stimulus-response items; and (D) a control group that received no prior training or experience. All subjects were trained on the specified stimulus-response items to the same criterion of mastery.

After familiarization training, the subjects were administered an opposition of cues test consisting of an equal portion of S-R pairs similar but not identical to the two classes of items used in familiar-

ization training. In other words, the single stimuli groups learned a list of items, half of which were familiar and half novel; Group C, the simultaneous group, on the other hand, was confronted with the task of learning all familiar items; and the control group, of course, learned all novel items, inasmuch as the subjects in this group received no prior training. Half of the total subject population learned the list to a criterion of one errorless trial by the recall method and are designed as the 100% mastery group. The remaining subjects learned the list to a criterion of 6 correct responses on a given trial (half the list) and are referred to as the 50% mastery group.

To further test the transfer effects of familiarization training, a reversal of cues test was administered all subjects. This test, proportional in length to that used for the opposition of cues test was also identical as regards the stimulus and response items. The essential difference was that the cues were reversed. That is, where circle figures were formerly paired with meaningful words in the opposition test, these figures were now paired with nonsense words and the square figures formerly paired with nonsense words were now associated with meaningful words. The recall method was also employed in this test as a measure of performance; but all subjects learned the list to a criterion of one errorless trial or to the 100% level of mastery.

In the Lawrence experiments, all the subjects (animals) were provided with both successive and simultaneous training. After administering the described dominance tests, a relearning test was given. In the present study, only the dominance tests were given.

The design of the present study was constructed so as to render possible a more thorough view of the nature of the "mediational process." A rough attempt has been made to envision a "mediational gradient." That is, subjects of group A, whose training consisted of circle figures paired with meaningful words should benefit from a strong "mediational process" while the subjects of group B, trained on square figures paired with nonsense words were required to learn under circumstances of a comparatively "weak mediational process."

Lashley, consistent with his notions regarding the discontinuity of discrimination learning feels that there should be no measurable generalization among stimuli when original training is restricted to a single stimulus situation, i.e., training on a single stimulus should be more difficult for subsequent discrimination learning than simultaneous training. As a result of this training on a single stimulus, there is established a set to react to this aspect of a subsequent stimulus situation comprised of the "familiar" stimulus and novel one.

In the Lawrence experiments all animals were first trained on the successive discrimination to respond to one stimulus and ignore another. The entire group was then trained on a simultaneous discrimination in which both cues were relevant; i.e., learning of the discrimination could be achieved on the basis of either cue or both. (The "preferred cue" was indicated by this choice). It may be recalled that this procedure differs somewhat from the one employed in the present study in that the subjects of the latter study received differential training in which all stimuli was relevant. At any rate, Lawrence's findings indicate that

discrimination learning is facilitated as a result of prior training and is faster on a familiar cue than it is on a non-familiar cue. This facilitation of learning was not restricted to the initial stages of learning but was evident throughout all tests administered.

1. When subjects are tested with stimuli differing by the same property as that received in familiarization training, learning on these test stimuli is facilitated.

The results of the present study also indicate a facilitative effect on discrimination learning as a result of familiarization training. The mean number of errors for the four experimental groups demonstrated, on the opposition of cues test, a very clear superiority of all training groups over against the control group.

Of significance here, however, is the differential performance of the three training groups. Group A, a single S-R group, trained on circle figures paired with meaningful words is reliably superior to the second single stimulus group trained on square figures paired with nonsense words, group B. Even more interesting is the slight inferiority in the learning rate of group B to the simultaneous or mixed group C, trained on both classes of stimulus-response items. On the surface one is prone to view these results as functionally related to the unequal difficulty of the items in the training lists of the three groups. That is, it is not a "mediational process" that is altering discriminability but rather the unequal difficulty of nonsense words as compared with those of high meaningful content. Therefore, group C, receiving training on half the meaningful items should perform with fewer errors

than group B, method of training notwithstanding.

A further analysis of the results, particularly those of the reversal test would tend to render such a view untenable. The mean error score of group B is significantly smaller than that of group C although larger than that for group A. Worth considering here is the possibility that in this type of learning situation, utilizing human subjects, the opposition of cues test may not be a crucial measure of the strength of association. Despite the fact that subjects of all groups considered thus far learned the discrimination to the 100% level of mastery, it is the opinion of this writer that there exists no justification for concluding that the relative habit strengths are equal solely in the basis of results on the opposition of cues test.

Such conclusions are not at all contrary to those stated by Lawrence. It might be recalled that he assumed that changes in the mediating process are of a gradual and continuous nature. On the basis of obtained results in the present investigation, it would seem essential to add the following:

II The degree of facilitation is dependent upon the type of familiarization training received.

(a) If familiarization training is restricted to a single S-R class of items, there will result a decrease in discrimination errors in subsequent tests.

Basic to stimulus-response interpretations is the assumption that discrimination learning is continuous, i.e., there are cumulative effects

of training from its beginning until the maximum habit strength is achieved. In Spence's words, discrimination learning involves "...a cumulation process of building up the excitatory tendency." Now it is apparent that the excitatory potential of meaningful words is greater than the nonsense words at the outset of training, and so the subsequent superiority resultant from further training would be anticipated. It is agreed that even though the stimulus-response association may be regarded as a unit, there does exist, in the initial stages of learning, some learning of the stimulus as well as the response separately. The discrimination process envisioned by the S-R theorists requires only that such learning be continued until the difference in excitatory strengths of the S-R pairs is sufficiently great as to make them discriminable from the difference in excitatory strength of other pairs. It need not be necessary either to dissociate learning from performance or postulate a separate "mediational" process to account for this build-up in association. Differences of this nature may be explained in terms of dimensional attributes of the stimulus or response such as intensity, quality or the like. In serial lists consisting of mixed items such as the one administered to the mixed group in the present study, intralist generalization and/or perseveration would appear adequate to account for the reduced effects of training on subsequent test performance (Reversal test). In other words, while the effects of familiarization training point to an increased facilitation of discrimination learning for both single stimulus and mixed groups on the opposition of cues test, a more difficult test requiring the subject

to inhibit an old response, such as the reversal test, reveals impeding effects of training by the mixed method.

Lawrence feels that his "extension" of the stimulus-response conception of discrimination learning is essential to account for his findings indicating that it is easier to reverse a strong habit than it is to reverse a weak one. He further states that "the fact that the present formulation is an extension of concepts to be found in S-R theories of learning indicates that the phenomena of attention are not crucial distinction between the continuity and noncontinuity theories." This may well be but it has been regarded so by many including the discontinuity theorists. It would appear to this writer to be the only logical means by which the notion of a dissociation of learning and performance can be explained or justified.

It is felt that the findings of the present study do not confirm the necessity for an extension of stimulus-response theories such as that proposed by Lawrence. Indeed, this so-called extension would appear to be more a modification of sign-significate interpretations of discrimination learning.

In a comparison of the reversal results of the 100% and 50% mastery groups in the present study, contrary results were obtained. The 50% mastery group receiving simultaneous training and the control group reversed what is believed to be a weak habit at a faster rate than the comparable 100% groups.

These results are not consistent with the Lashley nor Lawrence formulations but would seem to be in accord with strict stimulus-response

conceptions. It may be recalled that Hull's postulate regarding momentary effective potential (reaction, sEr) considers and provides for the effect of competing responses. In essence, as applied to the above results, it would seem that the two classes of items on the familiarization and test lists (simultaneous group, in particular) are not compatible with one another. Hence, the rate of learning would be reduced as a result of familiarization training. This is borne out further inasmuch as the weak habit was reversed more quickly for the 50% group.

CHAPTER VI

SUMMARY

The purpose of the present investigation was to experimentally test the validity of the Lashley formulation particularly as it is refined by Lawrence; and to obtain information as to the nature of discrimination learning. It was suggested that while the relationship between stimuli and responses may be dependent upon two variables, a mediating and association process, the present design would demonstrate that the role ascribed to the processes is not identical nor comparable in humans.

The present study divided the total subject population of 64 subjects into four main groups in accordance with the type of familiarization training received: (A and B), single stimuli groups in which subjects received experience on only one class of S-R items, group A being trained on circle figures paired with meaningful words and group B trained on square figures paired with nonsense words; (Group C), a simultaneous or mixed group that was provided experience with both classes of S-R items; and Group D, a control group that received no prior training. After familiarization training all subjects were administered tests for dominance to determine the transfer effect of the "preferred" or "familiar" S-R items.

The experimental design was constructed so as to provide the subjects by prior training, (a) experience with one set of cues, (b) give training in which this and a second set of cues are equally relevant, and (c)

finally test for the dominance of these cues in subsequent discrimination responses. The underlying assumption being that as a result of prior training, a "mediating process" is established that functionally alters the discriminability of the relevant cues in such a manner that they become more distinctive and hence, facilitate learning of a new response.

Conclusions.

1. When subjects are tested with stimuli differing by the same property as that received in familiarization training, learning on these test stimuli is facilitated.

2. The degree of facilitation is dependent upon the type of familiarization training received.

(a) If familiarization training is restricted to a single S-R situation class of S-R items, there will result a decrease in discrimination errors in subsequent tests.

3. The influence of familiarization training is not restricted to the initial stages of learning but tends to facilitate the learning of more advanced or complex tasks.

4. When the relative habit strength of two tasks is varied, it will be easier to reverse the stronger habit than the weaker one.

(a) However, such facilitation appears evident only when the familiarization training is restricted to the single stimuli type situation.

The findings of the present study, in the opinion of the author, do not confirm the necessity for an extension of Stimulus-Response interpretations of discrimination learning such as that proposed by Lawrence.

It is felt that the obtained results, in their entirety, may be adequately explained or interpreted within the confines of a unitary conception of habit formation as described by Hull and Spence.

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