A TEST OF INCREMENTAL AND ALL-OR-NONE THEORIES OF ACQUISITION BY A MEASURE OF RETENTION OF PAIRED-ASSOCIATE LEARNING

APPROVED:

Earl W Kooker

Major Professor

Paul Enochs

Minor Professor

Dwane Kingery

Dean of the School of Education

Robert B Toulouse

Dean of the Graduate School

A TEST OF INCREMENTAL AND ALL-OR-NONE THEORIES OF ACQUISITION BY A MEASURE OF RETENTION OF PAIRED-ASSOCIATE LEARNING

THESIS

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

Robert L. Breckenridge, Jr., B. A.
Denton, Texas
August, 1966

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

Is learning a gradual building process, an accumulation of experience that eventually enables the organism to make the correct response? Or is learning "an all-or-nothing affair, like the setting of a switch," as proposed by Guthrie (11, p. 97)? If the ability to understand the influence of all of the performance variables upon the progress of behavioral change in the learning situation were available, it would be relatively easy to determine whether a single acquisition function applies to all learning, and if so, the nature of that function. In the present absence of that ability, alternative theories have been offered. One theory accepts the typical performance curve at face value and holds that learning is a gradual process. This is the incremental or continuity view of learning. The second theory proposes that learning is sudden and insightful. Supporters of this all-or-none or noncontinuity view of learning believe that learning occurs in a single trial, but that factors affecting performance in the situation obscure this phenomena. Comparisons of the two positions have been presented by several authors (3, 5, 13, 18, 23, 24, 44).

The Incremental Position

Thorndike, an early associationalist, proposed the law of effect, stating: "When a modifyable connection between a situation and a response is made and accompanied by a satisfying state of affairs, that connection's strength is increased . . ." (36, p. 176). He defined a "satisfying state of affairs" as one which the organism does nothing to avoid, perhaps even doing such things that might attain or preserve it (36).

Probably the most vigorous support of the incremental position, however, has come from the behavioral systems of Hull (14, 15, 16, 22) and Spence (35). They have proposed that learning is a function of the number of reinforced trials according to the equation

$$_{S}H_{R} = 1 - 10^{-aN},$$

where $_{S}H_{R}$ (habit strength) varies from zero to 1.00 as a total range and a is an empirical constant of the order of 0.03 as stated in the original postulate (14). Performance, the demonstration of the occurrance of learning, however, according to Hull and Spence, cannot be measured, even though learning has taken place, until reaction potential ($_{S}E_{R}$) is greater than the reaction threshold ($_{S}L_{R}$).

Hull explains that "often more than one reinforcement is required before a reaction potential . . . becomes great enough to evoke the reaction (R). This gives rise to the concept of reaction threshold" (15, p. 101). As used in neurophysiological, psychological, and behavior theory and empirical practice, the term threshold implies in general a quantum of resistance or inertia which must be overcome by an opposing force before the latter can pass over into action (16). So defined, the threshold concept fits many natural situations to which it is not customarily applied. The reaction threshold is defined as the minimal effective reaction potential which will evoke observable reaction, *i.e.*, no reaction will occur, unless

$$_S\dot{\bar{E}}_R - {_S L_R} > 0$$

where $_S\dot{\bar{E}}_R$ represents momentary effective reaction potential. This difference is called the "suprathreshold effective reaction potential" (16, p. 324).

It is an everyday observance that organisms vary in their performance even of well-established, habitual acts from occasion to occasion and even from instance to instance on the same occasion. This means that reaction potential is subject (16) to momentary behavioral oscillation ($_SO_R$). Even when the strength of a reaction potential has become stabilized at a value well above reaction threshold, and the stimulus evokes its reactions with a considerable degree of consistency, both the amplitude and the latency of the reaction oscillate from trial to trial. Behavioral oscillation, then, has the effect of reducing reaction potential, *i.e.*, the probability of a response, from moment to moment. A response occurs if reaction potential is suprathreshold, but on a given trial, whether it is above or below threshold depends in part upon the oscillation function.

The All-Or-None Position

Guthrie, on the other hand, was an early advocate of an all-or-none theory of learning (10, 11, 39). This position maintains that conditioning is complete in a single trial and that learning is a function of simple contiguity; that is, that the connections between a response and a stimulus in whose presence it occurs is fully established in just one pairing. In his text, *The Psychology of Learning*, Guthrie states:

> In other words, it may be that the law of recency describes one of the fundamental characteristics of associative learning and that the results of frequent repetition depend on the enlistment of more conditioners, not on the strengthening of the association of any single conditioner (11, p. 97).

> I believe that the hypothesis that conditioning involves a definite rerouting of impulses from sense organs, and that the rerouting persist until further conditioning alters it is more sound than the hypothesis that associative strenth varies directly as the number of pairings (11, p. 97).

To account for the gradual course of most performance functions, Guthrie further states:

> The attainment of perfection demands that awkward and useless movements be detached from their cues as well as that useful movements be attached to cues (11, p. 101).

> . . . the law of frequency is not a fundamental characteristic of conditioning. The observed effects of repetition are not to be explained in terms of increased associative strength with added repetitions, but in terms of the enlistment of added conditioners which is normally the result of repetition (11, p. 101).

In other words, Guthrie holds that "(a) any stimulus which once accompanies a response . . . becomes a full strength cue for that response. (b) This is the only way in which stimulus patterns not now cues for a particular response can become direct cues for that response" (39, p. 342). If a certain stimulus pattern is present while a certain response is made, a learned association results; and furthermore, not only is this a sufficient, but also a necessary condition of learning. It is not, of course, sufficient to demonstrate that learning has occurred.

Finally, the strength of the association between the stimulus pattern and the response pattern is held to be established fully through once pairing the two. This statement is clearer when it is understood that there is an explicit distinction made between (a) establishing _association_ of a response with a stimulus pattern and (b) future _elicitation_ of that response by a stimulus pattern. Elicitation of a particular response upon presentation of certain stimuli depends in Guthrie's theory upon a variety of other factors in addition to whether the response has become associated with those stimuli. Such additional factors (39) are, for example, (a) whether all stimuli are present, and (b) whether the stimuli or a part of them have accompanied some incompatible response in the interim.

It will be recalled that in Hull's theory, the probability of a response was a function of reaction threshold, behavioral oscillation, and reaction potential. In Guthrie's theory, "the probability of any response's occurring (P_{RY}) at some specified time is an increasing monotonic function (x) of the proportion (N) of the stimuli present which are at that time cues for that response (S), *i.e.*,

$$P_{RY} = (N_S\ )^{x}$$"

(39, p. 348).

More recently, Estes and others have supported the all-or-none position (1, 2, 7, 8, 27) on the basis of statistical probability. They have proposed that rather than attempting to develop an entire theoretical system such as Hull's, miniature theories of limited application but capable of reliable prediction in the form of mathematical models can be constructed.

Purpose

Recent research by Rock (29, 30, 31) has found that subjects learning a list of paired-associates under conditions requiring one-trial learning are capable of learning a list of paired items in as few a number of trials as subjects learning similar lists of paired-associates under a condition using repetition. It was suggested that this could be offered as support of the one-trial learning position. It has been suggested by others, however, that even though Rock's results are reproducible, they are the results of artifacts (25, 26, 32, 38, 40, 41).

It appears that there are several possibilities that could account for Rock's results. Rock, in his study failed to control for item-selectivity within his experimental group, in this study to be called the drop-out condition or DOC. The DOC subjects may have learned a list of easier pairs than the control subjects. The removal of all pairs which a DOC subject failed to learn on a given trial provided an opportunity for the selection of relatively easy pairs, therefore, the new pairs became part of a list that of necessity was easier than the original list.

It is also possible that Rock's design was not sufficiently sensitive enough to discriminate between the two conditions. Since subjects in either group could attend to and learn only a few pairs in any one trial, it is suggested that the task of the experimental group was easy enough so that no differences between conditions could be found.

Hullian incremental learning theory proposes that evidence of learning occurs only after reaction potential has surpassed the reaction threshold, although sub-threshold learning may have taken place. It would follow, then, from

Hull's theory, that reaction threshold for a given pair that has been reinforced one or more times but not yet demonstrated as learned would be greater than the reaction potential for a new pair, *i.e.*, one for which the reaction potential would necessarily be zero. Assuming that both new and repeated items were learned on the next trial, it is probable that the reaction potential of the repeated pair would be at a greater distance above the threshold value than would the reaction potential of the new or one-trial pair. It follows, also, that after an intervening period there would tend to be a reduction of these reaction potentials, with the probability that the lower value of the reaction potential for the one-trial pair would more quickly fall below the threshold value.

A one-trial position, however, would contend that as long as a repeated pair has not been demonstrated as learned, it would have no more "associative strength" than a completely new pair. Similarly, if both were learned on the next trial, both would be learned to full and equal strength. It would also follow that after an intervening period, the probabilities that one or the other had been retained would be approximately equal.

Statement of Hypotheses

On the basis of the above considerations, two hypotheses are offered. First, it is hypothesized that after an intervening task, a greater number of pairs learned to a criterion of one correct association by subjects under the repetition condition will be recalled than will pairs that have been learned by subjects under the one-trial learning condition. And second, it is hypothesized that there is item-selection, i.e., learning of easier pairs by the subjects under the one-trial learning condition, and, therefore, the lists learned by this group are more readily learned than lists learned by the corresponding group under the repetition condition.

Review of the Literature

In the 1930's and the 1940's, the primary continuity-noncontinuity debate was not between two S--R positions as presented above, but rather between S--R theories supporting the continuity position and cognitive theories supporting the noncontinuity position (18). The question posed at that time was: does the organism, before it learns a discrimination problem, i.e., before it responds systematically to the positive stimulus cue and while it may be responding systematically to other stimulus cues, learn anything about (form any association with) the positive stimulus cue? The noncontinuity position answers negatively. It holds that during the pre-solution period, the organism may be responding systematically to other cues, e.g., position, and thus learning about them, but it does not learn anything about the "to-be-finally-learned set of discriminanda" (34, p. 264).

Not until the organism begins to respond to the relevant set of discriminanda, does it learn anything about the discrimination involved, or "from then on only are his 'bonds' being strengthened" (19, p. 112). According to the noncontinuity theorist, the presolution period represents an attempt, on the part of the organism to solve the problem by trying out various hypotheses, one after the other, until it discovers the correct one. These hypotheses are simply systematic response tendencies. The major point of this noncontinuity theory is that while the organism is responding on the basis of an incorrect hypothesis, he learns nothing at all about those cues that are relevant to the correct solution (19).

After a period producing many articles on the controversy, general experimental results appeared to support the S--R continuity theorist more so than the cognitive noncontinuity theorist (18). The argument was renewed, this time within the ranks of the S--R theorist, in 1957 when Rock published an article on research he had been conducting. In a novel experimental design, he found results that he concluded were evidence in support of a one-trial learning theory. This one article created such a furor that since that time no less than twenty-four other articles have been published either supporting or criticising, or contributing new evidence either in favor of or contradicting his position.

In a paired-associate learning task designed by Rock (29), each experimental subject was given only a single trial on which to learn each pair. Following each study-trial, the subject was given a test-trial. All pairs to which the subject incorrectly responded were replaced by new pairs, while pairs on which the subject was correct were retained in the next study-trial. Therefore the subject had only one exposure to an unlearned pair, so learning could only take place on a single trial. The control group, however, saw the same list on every trial. Rock found that his experimental group learned eight paired items in approximately the same average number of trials as did the control group. His conclusion was that repetition does not seem to be of value in forming associations.

Rock himself recognized factors that might influence or cause differences in performance. He suggested that for every subject there are certain pairs which are easier to learn than others. This being the case, the easy pairs may be the ones which were learned on any given trial, while the difficult ones were eliminated and replaced by new pairs. The new pairs substituted were not necessarily easy, but the reconstituted list on the whole was probably not as difficult as that with which the control group was faced on a corresponding trial.

In a later study, Rock and Heimer (30) conducted a series of four experiments attempting to eliminate certain objections to the original study. One objection was that if any wrong associations were formed, subjects in the control group had to overcome them, while subjects in the experimental group did not since all pairs which they failed to get right on any trial were eliminated. A second objection was that the technique was not sufficiently sensitive to reveal a possible advantage for pairs previously experienced. Rock stated this objection as follows:

> Suppose that repetition has tended to establish some sub-threshold linkages between pairs which Ss in the control group did not yet get right. Still, it might be argued, that on any given trial only a few of these pairs can be expected to be learned because of the difficulty created by intra-list interference. Since it is not too difficult for Ss in the experimental group to learn a few pairs on any trial, the result is that Ss of both groups learn about the same amount per trial, and thus the number of trials to criterion is about equal for the two groups (30).

In other words, it might be that the number of trials to criterion is not a sufficiently sensitive measure. A third objection was that the subjects who got new pairs substituted for wrong ones had a possible advantage because many of these may have been, for the individual subject, easier than the old unlearned ones were for the subjects who learned by the traditional method of repetition. If so, the disadvantage of difficulty may have offset the advantage of repetition for the control group.

Rock felt that the findings of his second series of experiments, reported in 1959 (30), confirmed his previous work and, by eliminating possible flaws in the earlier experimental design, cast considerable doubt on the incremental theory of forming associations. It is important to note that Rock's acquisition theory is not the classical all-or-none theory. He does not assume that learning becomes full strength after one correct association, but appears satisfied to accept some form of an incremental theory to explain the results obtained in the various studies of overlearning. He observes that

> . . . it seems clear from experience in daily life and from results of experiments on overlearning that associations become particularly strong and dependable with repetition. The only conclusion to be drawn is that repetition will have a beneficial effect upon an association only after it has been successfully established.
>
> It is probable that failure to distinguish between the influence of repetition before and after initial acquisition has contributed to the widespread belief in the incremental theory (30, pp. 14-15).

The first publication to appear as a direct result of Rock's research was by Wogan and Waters (42). Their study was designed to replicate Rock's original experiment and, in addition, to test the hypothesis that the control (repetition) group would relearn more rapidly than the experimental (one-trial) group after an interval of one week. The results for original learning were in agreement with those obtained by Rock. In relearning, the experimental group was superior at the .05 level of confidence. It was suggested by these authors that the substitution procedure permits the experimental group to select an easier list than that of the control group.

The first extensive examination of Rock's findings was made by Clark, Lansford, and Dallenbach (4). The purposes of this study were (a) to discover whether Rock's results could be duplicated in another laboratory, and (b) to determine whether his results were artifactual. It was found that the original results could be reproduced. In an experiment designed to determine if idiosyncratic differences in difficulty among the stimulus cards were present, it was concluded that this was not responsible for the results found either by Rock in his two studies (29, 30) or by Clark _et al_.

In another experiment by Clark _et al_. (4), an attempt was made to eliminate or restrict the use of mnemonic devices by shortening the exposure time of the items and eliminating the pause between items. The results indicated that the experimental subjects, learning under Rock's substitution method, required significantly fewer trials to learn a twelve-pair list than did the control subjects, who learned under the repetition condition. While it was pointed out that on the first test-trial the experimental subjects had learned approximately 30% more correct responses than had the control subjects, it was emphasized that this difference was not statistically significant. It was suggested that: (a) mnemonic devices were not responsible for Rock's results; and (b) that the task of the subjects learning under the experimental condition is not made easier by elimination of the difficult stimulus cards by some process of natural selection, but rather the task of learning by repetition is made more difficult, by way of associative interference, when the cards not learned are retained within the learning series.

As a supplementary experiment six months after the above experiment, those subjects still available were recalled and tested for retention. The subjects of both groups were presented with the stimulus series that they had previously brought to criterion. The method used for all subjects at this time was the classical repetition method. Though those subjects available were too few in number to warrant statistical treatment, results were quite similar to those in the above experiment, with experimental subjects reaching criterion on about half as many trials as the control subjects.

Kristofferson (20) modified Rock's original experiment by eliminating correct responses for both groups as well as substituting new pairs for unlearned pairs in the experimental group. Using pairs of nonsense syllables, he found that when subjects were required to spell out both syllables, control subjects, i.e., those under the repetition condition, reached criterion in fewer trials than did experimental (one-trial) subjects.

Rock and Steinfield (31), in rebuttal to Kristofferson's (20) findings, found that when subjects were required to pronounce nonsense syllables, there was no difference in trials to criterion between control and experimental groups. Where the subjects were required to spell the response syllable, however, Rock and Steinfield found a significant difference in favor of the control (repetition) group as had Kristofferson. In a similar experiment, after the fourth study-trial, a recognition test of the matching type was administered to a group which had been required to spell the response syllable, and no significant difference between control and experimental groups was found. When pronunciation groups were compared to spelling-out groups, it was found that the pronunciation group had a significantly higher number of correct associations than did the spelling-out group. It was suggested that spelling-out leads to a fragmentation into parts of what in the pronunciation method is a unitary whole, and that "perhaps the trace is less available in the spelling-out group because it has a somewhat attenuated unity character" (31, p. 824).

The first significant indication of artifactual interference in Rock's results was reported by Reed and Riach (26). They pointed out that Rock's position rested essentially on a failure to reject the null hypothesis, yet his control and experimental groups, in addition to being under different conditions, were also given different instructions. It was pointed out that it is generally accepted that the influence of set is an important variable in the learning process. It was considered possible that part of Rock's results were due to a differential set between his control group and experimental group.

Lockhead (21) proposed that in Rock's studies, since the subject was shown a pair to be learned for three seconds and then allowed a five-second interval before the next pair appeared, the rate of presentation allowed a total of eight seconds in which a pair could be practiced covertly. When the rate of presentation was increased, it was found that evidence for one-trial learning disappeared. Learning, therefore, may have been achieved by gradual strengthening, but the strengthening took place in an unobservable manner.

Underwood, Rehula, and Keppel (38) also raised the question concerning Rock's procedure of whether the insertion of new pairs (and the dropping of missed pairs) for the experimental group may not have produced a factor or factors which facilitated learning. Thus, if one assumes a gradual buildup of associative strength, the negative effects produced by the withdrawal of items having some associative strength, but not enough to produce correct association, might be counteracted by a positive effect resulting from the insertion of new items. It was pointed out that it would not be reasonable to expect the positive and negative effect to be of equal value, one canceling the effect of the other, and having, therefore, no significant effect on overall performance.

Underwood et al. indicated the most prominent possible factor was change in item difficulty; the pairs used to replace missed pairs may have been easier to learn than those that were replaced. To test this hypothesis, number-bigram pairs were used. Half of the bigrams had low associative conncection between the two letters (RZ), and half had high associative connections (GO). Three groups were used. The experimental group learned a twelve-item list by the drop-out method described above. The first control group learned the same twelve-item list the experimental group began with, but learned by the classical method of repetition. The second control group learned by the classical method also, but each subject in this group learned one of the lists on which a subject in the experimental group finally reached criterion. Results from this experiment found that the second control group needed significantly fewer trials on which to reach criterion than did either the first control group or the experimental group, and that the first control group needed significantly fewer trials than did the experimental group. It was also found that item selection did occur since the final lists learned by the experimental group contained a significantly higher percentage of high association bigrams than did the lists of the first control group.

In a similar experiment, Underwood *et al.* used the same type pairs as had Rock, *i.e.* number-letter pairs. Once again they found the second control group, which used the final list of the experimental group, to need significantly fewer trials to reach the criterion of one perfect trial than did the experimental group. There were no significant differences between either the first and second control groups or between the first control group and the experimental group, but differences were found in the same directions as in the experiment above using number-bigram pairs.

Since there was no significant difference between the two control groups, another experiment was designed. Two lists of eight items each were selected from those pairs seen by the experimental (one-trial) group in the above experiment. One group of items was selected to form an easy list based on the selection-index derived from the experimental subjects, *i.e.*, the eight most often learned items; and the other group formed a difficult list based on the same index, *i.e.*, the eight items least often learned. Subjects then learned both lists in counterbalanced order. They were presented on a memory drum for ten trials each under the usual anticipation learning procedure with four ordered variations for each list. The response measure was the mean number of correct anticipations given in ten trials. The number of correct anticipations for the "easy" list was significantly higher ($p < .01$) than for the "difficult" list. Thus the list made up of items judged to be easy as determined by the selection-index of the above experimental group was learned much more rapidly than the list judged to be difficult by the same index. The results for the two lists appear to support the hypothesis that there is clear item-selection by the experimental group. This is in accord with results found by Williams (40, 41) and Postman (25).

In another study by Schwartz (32), two groups were given a study-trial and a test-trial on a list of eighteen number-word pairs. The procedure in this study involved interchanging the items of the unlearned pairs in such a way that if pairs A-B, C-D, E-F, and G-H were presented on the first trial and pair A-B were learned, on the second study-trial experimental subjects were presented with A-B (again) and pairs such as C-F, E-H, and G-D, while control subjects were presented with the original list again. Control subjects were found to surpass experimental subjects in the number of critical pairs correct on the last two test-trials, in spite of the fact that differences in difficulty of items favored the experimental group.

Estes and others (6, 7, 9, 17) have taken a mathematical approach to the problem of the nature of the acquisition function. Estes (7) proposed that if learning were an "all-or-none association between stimulus and response, we expect that an individual S who makes Response A, say, on the first trial with a given stimulus will not shift to B on subsequent tests" (7, p. 440). To test this, Estes proposed using the RTT paradigm (9) in which the subject has only one response to an item reinforced and is then given two test-trials. Since in his experiment using this paradigm, the proportion of non-correct (N) items on the first test-trial that became correct (C) on the second test-trial, i.e., $C_2:N_1$, was nearly zero, it was concluded that this could be interpreted as support of the conditions as presented above of his all-or-none theory. Estes argued that this ratio should have been greater than zero if non-correct items on the first test-trial had actually received some associative strength on the learning-trial.

Seidel (33) studied the usefulness of the RTT paradigm as used by Estes et al.(9) to support his all-or-none theory. Estes' results indicated that there was no difference in retention between one and two reinforced trials if no test-trial intervened. Thus these data challenge the principle that retention of correct associations increases with the number of reinforcements per se. Results of Seidel's study, however, indicated that any conclusive theoretical statement "stemming from use of the RTT paradigm would still be premature" (33, p. 822).

Studies by Underwood and Keppel (37) and Wollen (43) found that, as had Rock, Estes had failed to control for a difficulty factor in learning. Other methods used by Estes were also questioned on the basis of sound experimental technique. Underwood and Keppel concluded that Estes' results could not be offered as evidence of support for a one trial learning theory, because they are easily accounted for by present incremental theories as well.

The present state of the controversy, then, is somewhat ambiguous. Rock (29, 30) has reported what he concluded was sufficient evidence for a one-trial acquisition theory. Clark, Lansford, and Dallenbach (4) have supported Rock and claim to have resolved some objections based on experimental design. On the other hand, other studies (20, 21, 25, 26, 32, 38, 40, 41) have presented evidence refuting the study by Clark _et al_. (4) and indicating that there is a very valid question of artifactual interference in Rock's results. Similarly, the studies by Estes (7, 9) are also criticized (33, 37, 43) for failure to control certain variables which might have affected his results as well as for using an experimental design that is of questionable reliability.

Experimental Method

Subjects

The subjects were fifty-one students from undergraduate education and psychology classes and from residents of one of the men's dormitories at North Texas State University. There were thirty-one men and twenty women ranging in age from seventeen to forty-one. Volunteers were requested from those sources during the first six-week period of the 1966 Summer Session. The students were asked to sign an appointment sheet that was circulated through the various classes and the dormitory.

There were three groups of subjects, two control groups, C_1 and C_2, and one experimental group, the drop-out condition or DOC. Since the nature of the task for a given C_2 subject was determined by a corresponding DOC subject, it was necessary for purposes of scheduling to place subjects into groups according to the following procedure. The first of three subjects was randomly placed in either C_1 or DOC. If he were placed in C_1, the next subject was placed in DOC and the third in C_2. If the subject were placed in DOC, however, the second subject was placed randomly in either C_1 or C_2, the third subject being placed in the remaining group. There were a total of fifty-one subjects with seventeen subjects in each group.

Materials and Apparatus

The material learned consisted of paired nonsense syllables of 47% to 53% Glaze (12) associational value. Nonsense syllables were selected because they are less amenable to mnemonic devices than are the letter-number pairs used by Rock in his original study (29). The syllable pairs were typed on white 3" x 5" cards, each syllable approximately centered in its half of the card. On the opposite side of the card was typed the first or stimulus member of the pair. A pool of eighty-four pairs was prepared. All pairs were randomly constructed except that no letter appeared more than once in either of the syllables. The order of the total eighty-four pairs was determined by a table of random numbers with the single condition that no letter was repeated in any two consecutive stimulus-items. An opaque projector was used to present the items to the subjects.

Procedure

The subjects were seated at a table facing the wall and about four feet from it. The opaque projector was to the right and about two feet behind the subject. The subjects were instructed to remain facing the wall at all times. All three groups were required to learn a list of ten pairs of nonsense syllables.

For all groups a practice list of four pairs was presented for one study-trial and one test-trial. Since Rock and Steinfield (32) found that spelling-out of syllable pairs impeded learning, the subjects were told to pronounce each syllable at the rate of about one per second. They were also told that their task was to learn as many pairs as possible on a given trial. Each card was exposed just long enough for the subject to pronounce the pair, with an interval between cards no longer than necessary to expose the next card. The mean exposure rate for this procedure was about four seconds per card.

Control 1 (C_1).-- Seventeen different lists of ten pairs each were taken from the ordered pool of eight-four pairs. Pairs numbered one through ten formed the first list, pairs six through fifteen formed the second list, etc., such that the last five pairs of one list became the first five pairs of the subsequent list. The only variation in construction of the lists involved the sixteenth and seventeenth lists. The sixteenth list was formed of pairs seventy-six through eighty-four and pair number one. Similarly, the seventeenth list was composed of pairs eighty-one through eighty-four and one through six. This ordering resulted in using every pair in two different lists for C_1 subjects with the exception of pairs numbers one and six, which were used three times each.

The method of learning was that of alternate study- and test-trials. Test-trials were given simply by using the reverse side of the cards on which the stimulus-terms were typed. On the test-trials many items which were correctly associated were removed from the list and set aside. While having the effect of shortening the list, this procedure prevented overlearning beyond one correct association. Study-trials were continued until all ten pairs were correctly associated. Following each study-trial, a test-trial was given on which each stimulus-term was shown for five seconds. If the subject gave a correct response at any time before the next card was shown, it was counted as correct. Between successive cards on the test-trial, there was a three-second interval. After each study-trial and test-trial, the remaining cards in the list were shuffled. The subjects were never shown nor informed of the correct response on a test-trial. During the study-trials, the subjects were required to say aloud both the stimulus- and response-terms, and on the test-trials were required to say the stimulus-term aloud whether followed by the correct anticipation of the response or not.

Drop-out-condition (DOC).-- Each subject in this group was initially given one of the ten-item lists used by a subject in C_1. As in C_1, all pairs correctly associated were set aside. All pairs missed (wrong response or no response) on the test-trials were replaced with new pairs from the pool so that on subsequent study-trials only new pairs were presented. If the pool of items was exhausted before a subject reached the criterion of ten correctly associated pairs, replacements consisted of the items which the subject first missed. While these repeated replacement pairs were not new pairs, i.e., since they had been previously experienced, it was felt that since they were unlearned and had been followed by eighty-four other pairs, they would for all practical purposes be the equivalent of new pairs. Instructions given before learning informed the subjects that the pairs might change from trial to trial, these same instructions also having been given to the two control groups. Since for the DOC a thirty-second period was required after each test-trial to replace missed items, a corresponding period of thirty seconds was also inserted after each test-trial for the subjects in C_1 and C_2.

Control 2 (C_2).-- These subjects learned a ten-pair list in exactly the same manner as the subjects in C_1. However, the ten pairs learned by the subjects in this group consisted of the ten pairs with which some member of the DOC had achieved criterion. Thus each member of C_2 learned a different ten-pair list, the particular list being determined by a subject in DOC.

Conditions common to all groups.-- For all three groups, the interval between test- and study-trials was fifteen seconds. During intertrial intervals and after the ten pairs had been associated, all subjects were given a task of marking the answer slots in an IBM-type machine-scored answer sheet to prevent covert practicing of the pairs. One minute after the test-trial on which the tenth pair had been associated, a final or critical test-trial over all ten pairs brought to criterion was given. A record of all correct associations on this test-trial was kept.

Statistical Treatment

Since this study was designed to discriminate between one-trial learning and incremental learning, it was necessary to exclude from statistical treatment any items correctly associated on the first test-trial. This is due to the fact that they represent pairs that were learned in one trial by all groups while experimental conditions were identical for all three groups. To put them on an equal scale, the number of correct pairs were divided by the number of pairs available after the first test-trial. Retention scores on the final critical test-trial over all ten items, then, are a ratio score according to the formula

$$S_{CTT} = \frac{X_C - X_{C1}}{10 - X_1}$$

where S_{CTT} represents the critical test-trial score, X_C equals the number of pairs correct on the critical test-trial, X_{C1} equals the number of items correct on the critical test-trial which were also correct on the first test-trial, and X_1 equals the total number of items correct on the first test-trial.

In the study by Clark, Lansford, and Dallenbach (4), in which support for Rock's results was reported, it was noted that there were differences in mean number of pairs associated on the first test-trial between groups. For this reason, a _t_-test on mean number of pairs correctly associated on the first test-trial between C_1 and DOC was performed.

A test for homogeneity of groups was run as was a simple analysis of variance for both number of trials needed to reach criterion and critical test-trial scores between the groups. If C_2 took fewer trials to reach criterion than C_1 or DOC, then it was indicated that item-selection by DOC had occurred. If either C_2 or C_1 and C_2 learned the ten pairs in fewer trials than DOC, then it indicated that repetition is a major factor in learning, supporting the incremental position. If C_1 and C_2 recalled more items on the critical test-trial than did DOC, then it also indicated that repetition is an important factor in both learning and retention of paired-associates, again supporting the incremental position. Another test of rate of learning involved total number of errors made by each group in reaching criterion. A simple analysis of variance was run on total number of errors for each condition. If either C_2 or C_1 and C_2 made significantly fewer errors than did DOC, support of the incremental position and the importance of repetition in learning was demonstrated.

CHAPTER BIBLIOGRAPHY

1. Atkinson, R. C., G. H. Bower, and E. J. Crothers, An Introduction to Mathematical Learning Theory, New York, John Wiley & Sons, Inc., 1965.

2. Atkinson, R. C., and W. K. Estes, "Stimulus Sampling Theory," Vol. II of Handbook of Mathematical Psychology, edited by R. R. Bush and E. Galanter (3 volumes), New York, John Wiley & Sons, Inc., 1963.

3. Ausbel, D. P., The Psychology of Meaningful Verbal Learning, New York, Grune & Stratton, 1963.

4. Clark, L. L., T. G. Lansford, and K. M. Dallenbach, "Repetition and Associative Learning," The American Journal of Psychology, LXXIII (1960), 22-40.

5. Deese, J., The Psychology of Learning, New York, McGraw-Hill Book Company, Inc., 1958.

6. Estes, W. K., "All-or-None Processes in Learning and Retention," The American Psychologist, XIX (1964), 16-25.

7. ____________, "Learning Theory and the New 'Mental Chemistry'," Controversial Issues in Learning, edited by H. Goldstein, D. L. Krantz, and J. D. Rains, New York, Appleton-Century-Crofts, 1965.

8. ____________, "The Statistical Approach to Learning Theory," Vol. II of Psychology: A Study of a Science, edited by S. Koch (7 volumes), New York, McGraw-Hill Book Company, Inc., 1959.

9. Estes, W. K., B. L. Hopkins, and E. J. Crothers, "All-or-None and Conservation Effects in the Learning and Retention of Paired Associates," The Journal of Experimental Psychology, LX (1960), 329-339.

10. Guthrie, E. R., "Association by Contiguity," Vol. II of Psychology: A Study of a Science, edited by S. Koch (7 volumes), New York, McGraw-Hill Book Company, Inc., 1959.

11. ______________, The Psychology of Learning, New York, Harper & Row, 1935.

12. Hilgard, E. R., "Methods and Procedures in the Study of Learning," The Handbook of Experimental Psychology, edited by S. S. Stevens, New York, John Wiley & Sons, Inc., 1951.

13. ______________, Theories of Learning (Rev. ed.), New York, Appleton-Century-Crofts, Inc., 1956.

14. Hull, C. L., A Behavior System, New Haven, Yale University Press, 1952.

15. ____________, Essentials of Behavior, New Haven, Yale University Press, 1951.

16. ____________, Principles of Behavior, New York, D. Appleton-Century, Inc., 1943.

17. Jensen, A. R., "Serial Rote-Learning: Incremental or All-or-None?" Quarterly Journal of Experimental Psychology, XV (1963), 27-35.

18. Kimble, G. A., Hilgard and Marquis' Conditioning and Learning, New York, Appleton-Century-Crofts, 1961.

19. Krechevsky, I. A., "A Study of the Continuity of the Problem Solving Process," Psychological Revue, XL 1938), 107-133.

20. Kristofferson, A. B., Repetition and Paired-Associates Learning," Science, CXXXIV (1961), 2036-2037.

21. Lockhead, G. R., "A Re-evaluation of One-Trial Associative Learning," The American Journal of Psychology, LXXIV (1961), 590-596.

22. Logan, F. A., "The Hull-Spence Approach," Vol. II of Psychology: A Study of a Science, edited by S. Koch (7 volumes), New York, McGraw-Hill Book Company, Inc., 1959.

23. Marx, M. H., and W. A. Hillix, Systems and Theories in Psychology, New York, McGraw-Hill Book Company, Inc., 1963.

24. McGeoch, J. A., and A. L. Irion, The Psychology of Human Learning, New York, Longmans, Green and Co., 1952.

25. Postman, L., "Repetition and Paired-Associate Learning," The American Journal of Psychology, LXXV (1962), 372-389.

26. Reed, J. C., and W. D. Riach, "The Role of Repetition and Set in Paired-Associate Learning," The American Journal of Psychology, LXXIII (1960), 608-611.

27. Restle, F., "Sources of Difficulty in Learning Paired Associates," Studies in Mathematical Psychology, edited by R. C. Atkinson, Stanford, Stanford University Press, 1964.

28. Reynolds, J. H., "Repetition Factors in One Trial Learning of Paired Associates," The Journal of Experimental Psychology, LXV (1963), 362-367.

29. Rock, I., "The Role of Repetition in Associative Learning," The American Journal of Psychology, LXX (1957), 186-193.

30. Rock, I., and W. Heimer, "Further Evidence of One-Trial Associative Learning," The American Journal of Psychology, LXXII (1959), 1-16.

31. Rock, I., and G. Steinfield, "Methodological Questions in the Study of One-Trial Learning," Science, CXL (1963), 822-824.

32. Schwartz, Marian, "Transfer from Failed Pairs as a Test of One-Trial vs. Incremental Learning," The American Journal of Psychology, LXXVI (1963), 266-273.

33. Seidel, R. J., "Role of Repetition and Reinforcement in Learning," Psychological Reports, XIII (1963), 823-828.

34. Spence, K. W., "An Experimental Test of the Continuity and Non-Continuity Theories of Discrimination Learning," The Journal of Experimental Psychology, XXXV (1945), 253-266.

35. Spence, K. W., Behavior Theory and Conditioning, New Haven, Yale University Press, 1956.

36. Thorndike, E. L., The Fundamentals of Learning, New York, Teachers College, 1932.

37. Underwood, B. J., and G. Keppel, "One-Trial Learning?" Journal of Verbal Learning and Verbal Behavior, I (1962), 1-13.

38. Underwood, B. J., R. Rehula, and G. Keppel, "Item-Selection in Paired-Associate Learning," The American Journal of Psychology, LXXV (1962), 353-371.

39. Voeks, Virginia W., "Formalization and Clarification of a Theory of Learning," The Journal of Psychology, XXX (1950), 311-322.

40. Williams, Joanna P., "A Test of the All-or-None Hypothesis for Verbal Learning," The Journal of Experimental Psychology, LXIV (1962), 158-165.

41. ____________________, "Supplementary Report: A Selection Artifact in Rock's Study of the Role of Repetition," The Journal of Experimental Psychology, LXII (1961), 627-628.

42. Wogan, M., and R. H. Waters, "The Role of Repetition in Learning," The American Journal of Psychology, LXXII, (1959), 612-613.

43. Wollen, K. A., "One-Trial Versus Incremental Paired-Associate Learning," Journal of Verbal Learning and Verbal Behavior, I (1962), 14-21.

44. Wolman, B. B., Contemporary Theories and Systems In Psychology, New York, Harper & Brothers, 1960.

CHAPTER II

RESULTS

In an attempt to test between two acquisition theories, fifty-one students from the 1966 Summer Session at North Texas State University were divided randomly into three groups and required to learn ten paired-associates to a criterion of one correct association. Control Group 1 (C_1) learned a ten-pair list under the repetition condition, while the Drop-Out Condition (DOC) learned ten paired syllables under a condition requiring one trial learning. Subjects in Control Group 2 (C_2) learned the ten pairs learned by corresponding subjects in the DOC, but learned under a condition of repetition. Figure 1 represents the acquisition curves for all three groups. It can be seen that with each successive trial, the per cent of pairs learned increased. It can also be noted that all of the subjects in C_2 reached criterion by the eighth trial, but that it took fourteen trials before all of the subjects in C_1 or DOC reached criterion.

Homogeneity of variance of the mean number of trials to criterion for the three groups was tested by Bartlett's

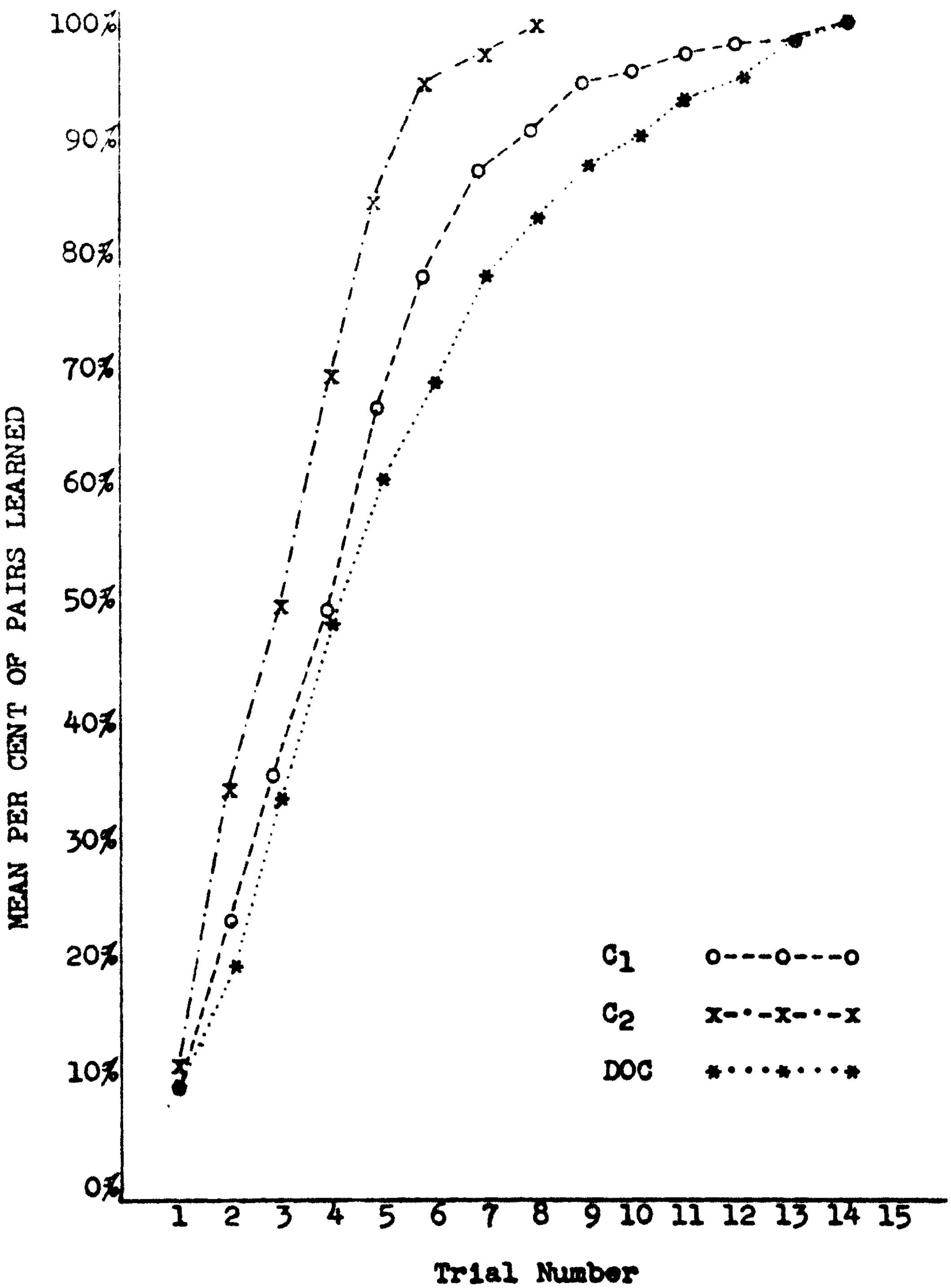

Fig. 1--Mean per cent of pairs learned on each trial.

Test and was found not to be significant at $p < .20$. Table I shows a summary of the analysis of variance which was performed on these data. Because a significant F value was

TABLE I

SUMMARY OF ANALYSIS OF VARIANCE FOR NUMBER OF TRIALS (T) TO CRITERION

Source of Variability	SS	df	MS	F	p
Between	59.57	2	29.785	4.24	.05
Within	336.94	48	7.020	. . .	. . .
Total	396.51	50	. . .	. . .	. . .

found, further analysis by *t* tests was conducted to determine which differences were significant. Table II contains the means and standard deviations of the three groups. Table III

TABLE II

MEANS AND STANDARD DEVIATIONS FOR NUMBER OF TRIALS TO CRITERION

Group	Mean	Standard Deviation
C_1	7.12	2.72
C_2	5.76	1.89
DOC	8.41	2.97

contains the *t* values which were obtained for C_1, C_2, and DOC. These data revealed that C_2 and DOC were significantly different in mean number of trials needed to reach criterion at a level greater than .01.

TABLE III

t VALUES FOR TEST OF SIGNIFICANT DIFFERENCES BETWEEN GROUPS IN NUMBER OF TRIALS TO CRITERION

Groups	Groups	
	C_2	DOC
C_1	1.691	1.320
C_2	. . .	3.096*

*Significant at $p < .05$.

Since there should have been no differences in performance on the first test-trial for C_1 and DOC, a *t* test was performed on the difference between mean number of pairs learned by these two groups on the first test-trial. The means and standard deviations of C_1 and DOC were 0.94 and 1.70, and 0.82 and 1.13, respectively. A *t* test yielded a *t* value of 0.119 which was not significant ($p < .90$).

A simple analysis of variance was performed to determine if there were significant differences between number of non-correct pairs (missed pairs or no response) on all test-trials excluding the final critical test-trial for the three groups.

The summary of data for this treatment is presented in Table IV. Variances were not found to be significantly different by Bartlett's test of homogeneity. Since this F value was

TABLE IV

SUMMARY OF ANALYSIS OF VARIANCE FOR NON-CORRECT (NC) RESPONSES

Source of Variability	SS	df	MS	F	p
Between	2,250	2	1,125	3.87	.05
Within	13,948	48	261	. . .	. . .
Total	16,198	50	. . .	. . .	. . .

also found to be significant, *t* tests were employed in the further analysis. The means and standard deviations of the non-correct scores are found in Table V. The *t* values which

TABLE V

MEANS AND STANDARD DEVIATIONS OF THE NON-CORRECT SCORES

Group	Mean	Standard Deviation
C_1	36.00	17.23
C_2	26.41	12.04
DOC	41.94	18.38

were obtained are presented in Table VI. These data revealed that there was again a significant difference ($p < .001$) between C_2 and DCC.

TABLE VI

$\underline{t}$ VALUES FOR TEST OF SIGNIFICANT DIFFERENCES BETWEEN GROUPS FOR NON-CORRECT SCORES

Groups	Groups	
	C_2	DCC
C_1	1.884	0.971
C_2	. . .	5.359*

*Significant at $p < .001$.

When Bartlett's test of homogeneity of variance was conducted on the critical test-trial scores (S_{CCT}), it was found to be significant at the .05 level. When a logarithmic transformation was performed, heterogeneity was still found. It was noted that the major factor in finding heterogeneity was the relatively large size of the variance of C_2 as compared with the variances of C_1 and DCC. It was also noted that other data of a similar nature on these same groups had indicated homogeneity. It has been found, however, that homogeneity of variance is not always a necessary assumption. Hays has reported that "when the data table represents an equal number of observations in each cell the requirement of equal error variance in each treatment combination population may also be violated without serious risk" (1, p.408).

An analysis of variance, therefore, was performed on the original data. The data used in the analysis of the critical test-trial scores is summarized in Table VII. Since the F

TABLE VII

SUMMARY OF ANALYSIS OF VARIANCE FOR CRITICAL TEST-TRIAL SCORES

Source of Variability	SS	df	MS	F	p
Between	0.406	2	0.203	3.27	.05
Within	3.003	48	0.062	. . .	. . .
Total	3.409	50	. . .	. . .	. . .

value was found to be significant, further analysis of the data was carried out by *t* tests. The means and standard deviations of the critical test-trial scores are presented in Table VIII. When the *t* tests were performed, significant

TABLE VIII

MEANS AND STANDARD DEVIATIONS OF THE CRITICAL TEST-TRIAL SCORES

Group	Mean	Standard Deviation
C_1	0.571	0.182
C_2	0.535	0.288
DOC	0.355	0.161

differences between C_1 and DOC ($p < .001$) and C_2 and DOC ($p < .05$) were found. The *t* values obtained are presented in Table IX.

TABLE IX

***t* VALUES FOR TEST OF SIGNIFICANCE OF DIFFERENCES BETWEEN GROUPS ON CRITICAL TEST-TRIAL SCORES**

Groups	Groups	
	C_2	DOC
C_1	0.436	3.673**
C_2	. . .	2.253*

*Significant at $p < .05$.
**Significant at $p < .001$.

CHAPTER BIBLIOGRAPHY

1. Hays, W. L., *Statistics for Psychologists*, New York, Holt, Rinehart & Winston, Inc., 1963.

CHAPTER III

DISCUSSION

The results in Table III and Table VI, as presented in Chapter II showed that C_2 differed significantly from DOC in both mean number of trials to reach criterion and mean number of errors (NC pairs). As with Rock's (4, 5, 6) studies, no difference was found in number of trials to criterion between the repetition group, C_1, and the one-trial group, DOC. Consequently, the hypothesis that there was item-selection, i.e., learning of easier pairs by the subjects under the one-trial learning condition, and, therefore, the items learned by subjects in the DOC were more readily learned, was supported. It would have been expected that there would have also been a significant difference between trials to criterion and/or number of errors for C_1 and C_2. The very fact that there was not prohibits a clear and concise statement about the true effect or extent of the item-selection that has occurred under the drop-out condition.

If, as Rock concluded, repetition had no effect on rate of learning in comparing C_1 and DOC; and if item-selection of easier items were the only factor in the significant difference between C_2 and DOC; then there should also have been a significant difference between C_1 and C_2.

Since there was not, it must be concluded that either (1) item-selection was not a factor and that some other factor or factors were responsible for the observed difference, or (2) item-selection was one of two or more factors which were responsible for the difference. If the first alternative were to be accepted, then the most probable factor that could be assumed to have affected rate of learning for the two groups would have been the repetition *vs*. one-trial conditions. Since there was no significant difference between C_1 and DOC, however, this position is not acceptable because under this assumption the repetition factor should have also favored C_1. The second assumption is the more probable of the two. It is quite possible that learning a ten-pair list is sufficiently easy to prohibit the differences between either repetition and one-trial conditions, *e.g.*, C_1 and DOC, or "difficult" and "easy" pairs, *e.g.*, C_1 and C_2, from being found. When, however, the combined effects of repetition and an easy list are compared with a one-trial condition, *e.g.*, C_2 and DOC, significant differences result.

In spite of any qualifications that might be placed on any interpretation of the effects of item-selection, it can be concluded that there was item-selection by the DOC group. This is in support of similar results found by Underwood, Rehula, and Keppel (7) and Postman (3). The fact that there is evidence of item-selection by a group under the drop-out condition places Rock's results (4, 5, 6) in question.

The results in Table IX, as reported in Chapter II, showed that, when retention of items learned to a criterion of one correct association was measured, subjects in C_1 and C_2 retained a significantly greater number of associations than did subjects under the DOC. Consequently, support was found for the hypothesis that, after an intervening task, a greater number of pairs learned to a criterion of one correct association by subjects under a condition of repetition will be recalled than will pairs that have been learned to the same criterion by subjects under the one-trial learning condition. These results, therefore, would appear to support Hullian incremental learning theory as opposed to some form of a one-trial learning theory as perhaps proposed by Rock (4, 5) or Estes (1, 2).

It is possible, however, that some objections might be raised to this interpretation of these results. It was noted in Chapter II that heterogeneity of variance was found on this portion of the data. It was also noted that the variances of other measures on the same groups were found to be homogeneous, and that it was only the relatively high variance of the C_2 group as compared to the variances of the other two groups which caused the heterogeneity. While it is felt that this is not sufficient cause to jeopardize the present interpretation of the results, it should be noted that even should C_2 be excluded from statistical treatment, the significant differences between C_1 and DOC ($p < .001$) more than adequately supports the hypothesis.

There is another possible objection a one-trial theorist might offer. Since the measure of one correct association was dependent upon the verbalization of that association by the subject, it is possible that a subject knew a pair well enough to be able to verbalize it but, because of uncertainty or some other reason, failed to do so. Such a subject in C_1 or C_2 would then have another reinforced trial with that pair, thus carrying learning beyond one correct association. A DOC subject, however, would be at the disadvantage of losing the item that had been learned but not verbalized by having it replaced by a completely new item.

There is also the effect of guessing to be considered. Any pair that was correctly guessed would have little likelihood of being recalled on the critical test-trial since it would in effect be an unlearned pair. This, however, would be more to the disadvantage of the repetition condition subjects since the likelihood of one of ten or fewer pairs being guessed after two or more study-trials would be greater than for the drop-out condition where ten or more pairs had been seen and could conceivably be used as guessing responses.

Another situation that might be construed as favoring the performance of the repetition group involves retroactive inhibition. The data in Table V, as presented in Chapter II, demonstrated that DOC subjects saw approximately forty-two different unlearned pairs before criterion was reached and the critical test-trial could be given. The C_1 subjects, while recording a mean of thirty-six incorrect responses before reaching criterion, saw only the same unlearned pairs. It might be argued, therefore, that the presentation of new pairs created greater retroactive inhibition with the retention of the previously learned pairs for DOC subjects than would presentation of previously seen pairs for the repetition group. It is equally feasible, however, to argue that it is probable that there was intra-list inhibition as well as retroactive inhibition for the repetition groups. It would not be expected, though, that these effects would cancel out each other. These, however, are arguments that would more likely be presented by an incremental theorist than an advocate of a one-trial acquisition theory. The one-trial theory would hold that there would be no difference between a new pair and an unlearned pair. It would follow, then, from a one-trial position, that intralist or retroactive inhibition would be no greater for either group.

Based on this experimental evidence and the assumptions made, it was concluded that item-selection by DOC subjects did occur and, therefore, that using results relating to number of trials to reach criterion by C_1 and DOC type groups to support a one-trial learning theory as Rock did is at best a questionable assumption. It was also concluded, with recognition of possible areas of objection, that the data on the measure of retention offer compelling support of an incremental theory of learning.

CHAPTER BIBLIOGRAPHY

1. Estes, W. K., "All-or-None Processes in Learning and Retention," The American Psychologist, XIX (1964), 16-25.

2. Estes, W. K., B. L. Hopkins, and E. J. Crothers, "All-or-None and Conservation Effects in the Learning and Retention of Paired Associates," The Journal of Experimental Psychology, LX (1960), 329-339.

3. Postman, L., "Repetition and Paired-Associate Learning," The American Journal of Psychology, LXXV (1962), 372-389.

4. Rock, I., "The Role of Repetition in Associative Learning," The American Journal of Psychology, LXX (1957), 186-193.

5. Rock, I., and W. Heimer, "Further Evidence of One-Trial Associative Learning," The American Journal of Psychology, LXXII (1959), 1-16.

6. Rock, I., and G. Steinfield, "Methodological Questions in the Study of One-Trial Learning," Science, CXL (1963), 822-824.

7. Underwood, B. J., R. Rehula, and G. Keppel, "Item-Selection in Paired-Associate Learning," The American Journal of Psychology, LXXV (1962), 353-371.

CHAPTER IV

SUMMARY AND RECOMMENDATIONS

The present study was undertaken to test the implications of two theories of learning, incremental and one-trial, as to the nature of the acquisition function. The following hypotheses were tested.

Hypothesis I. There is item-selection, *i.e.*, learning of easier pairs by the subjects under the one-trial learning condition, and, therefore, the items learned by these subjects are more readily learned.

Hypothesis II. After an intervening task, a greater number of pairs learned to a criterion of one correct association by subjects under a condition of repetition will be recalled than will pairs that have been learned to the same criterion by subjects under a one-trial learning condition.

The sample was composed of 51 students enrolled in undergraduate classes and undergraduates from a men's dormitory at North Texas State University, Denton, Texas. The total group included 31 men and 20 women whose ages ranged from 17 to 41 and whose classifications ranged from Freshmen to Graduates. These subjects were randomly divided among three groups.

The first group, C_1, learned a ten-pair list under conditions of repetition to a criterion of one correct association of each pair. Those pairs correctly associated were removed from the list and set aside for later use. The second group, DOC, also learned ten pairs of items to a criterion of one correct association. Unlearned pairs, however, instead of being repeated, were replaced by new pairs. The third group, C_2, while learning under the same conditions as C_1, learned the ten items brought to criterion by a corresponding subject in the DOC group.

Analysis of the data on number of trials needed to reach criterion showed an F value significant at $p < .05$, with C_2 learning in significantly fewer trials at $p < .05$. Similar results were obtained when total error scores were treated. An F value significant at $p < .05$ was obtained and the difference in total number of errors made between C_2 and DOC was found to be significant at $p < .001$, with C_2 making fewer errors. Statistical treatment of the critical test-trial scores found an F value significant at $p < .05$. While no difference between C_1 and C_2 was found, differences between C_1 and DOC, and C_2 and DOC were found to be significant at $p < .001$ and $p < .05$ with the DOC group retaining less than either C_1 or C_2.

On the basis of results obtained in this study, it was concluded (1) that item-selection of "easy" pairs by the group under the one-trial learning condition did occur, and

(2) the superior performance by the repetition groups as compared to the one-trial groups on the retention measure demonstrates clear support of an incremental learning theory as opposed to a one-trial or all-or-none learning theory. Both research hypotheses, therefore, were supported.

Rock had based his suggestion of support for a one-trial learning theory in part on the assumption that the material learned by both his control (repetition) and experimental (one-trial) groups was equivalent. He necessarily assumed, therefore, that no item selection by the one-trial group had taken place. This study has demonstrated that item-selection by a one-trial group did in fact occur. It was noted, however, that if item-selection of easy pairs were the sole factor in the superior performance of C_2 over DOC, then C_2 should also have learned in significantly fewer trials than C_1. Since the difference between C_2 and C_1 was not significant, it was suggested that repetition as well as level of difficulty of item was a factor in the difference in number of trials to reach criterion and number of errors made by C_2 and DOC groups.

A one-trial acquisition theory would hold that pairs learned to one correct association under either a repetition condition or a condition requiring one-trial acquisition are learned equally well. An incremental theory, however, would contend that the reaction potential for a repeated item learned to one correct association would probably be higher than the reaction potential for an item learned to the same criterion under one-trial learning conditions. The significantly superior retention scores for C_1 and C_2 offer clear support of the incremental position. It was noted, however, that it was possible that the repetition condition subjects had a factor which favored them. If a repetition subject, because he was not sure his response was correct or for some other reason, failed to respond when he actually knew the correct response, the pair would be presented again and would thus be learned beyond one correct association. A one-trial subject, however, would have no such opportunity. It was not felt that this was a significant factor in this study, however. With the above considerations, it was felt that clear support of an incremental interpretation of the acquisition function was demonstrated.

Recommendations

1. It is possible that the task involved, i.e., learning a list only ten pairs in length, is not sufficently difficult to test for superiority between repetition and one-trial groups. Lengthening the list might provide a better measure of the true nature of the learning which is taking place in this type of paired-associate learning. It should be noted, however, that lengthening of the list might make learning by the one-trial group too difficult

because of lack of familiarity with the material or excessive inhibition created by a very long list.

2. It is possible that repetition subjects did not verbalize a learned association because of unsureness or some other reason. A test of the matching type could be substituted for the recall type of test-trial used in this study. A more accurate measure of what pairs had been associated might be obtained by use of this recognition type of test.

3. Another type of measure that could have been used instead of the recall method on the critical test-trial is the savings method of learning. This method might provide a better measure of learning or provide new information concerning how learning took place.

APPENDIX

NONSENSE SYLLABLE PAIRS USED IN THE STUDY

1. KIQ-RUV
2. TUY-YAD
3. LAH-QUN
4. POV-WIQ
5. YUR-TIZ
6. QOZ-VAW
7. JIS-YOR
8. BOQ-PUJ
9. VAY-WIH
10. FEG-LUW
11. KUF-POB
12. QOT-PUK
13. JIR-VEB
14. LEH-KOC
15. SUJ-WAZ
16. ZAM-FIQ
17. BOP-HUZ
18. MIC-JUY
19. LUQ-SOZ
20. POY-QET
21. JAL-KIV
22. GOW-CEZ
23. NAJ-KEM
24. BUP-CES
25. XAN-VOZ
26. GEZ-QAF
27. KUD-VIW
28. VAB-TIS
29. WEM-VUT
30. KUB-WEH
31. VIP-GOH
32. ZEB-COQ
33. DUZ-HEB
34. KAR-QUC
35. NUH-BEW
36. BIJ-TUD
37. MEP-LUB
38. KAB-ZIM
39. NOL-KAM
40. FUW-MAQ
41. MIJ-DAK
42. NEY-KIX
43. WAH-LUJ
44. GEV-HAX
45. HUJ-KED
46. NOY-WUS
47. RIQ-FEJ
48. MUB-QIG
49. FOV-JEP
50. DUP-HEF
51. QIB-GEY
52. CUY-NEF
53. WOB-FEX
54. KUM-VOD
55. QIX-NAW
56. GAC-NOQ
57. KON-YAT
58. DAF-ZUG
59. PIV-BEK
60. VAQ-YUG
61. YIT-ZAD
62. RUK-ZEN
63. TAJ-NIR
64. SIQ-FAH
65. TEZ-PIJ
66. SOQ-MUN
67. FAP-GIJ
68. TIQ-FEC
69. XUN-MIH
70. YAF-GIZ
71. FIP-QAR
72. NAC-PEQ
73. BOZ-NIW
74. DUF-XOW
75. YAX-JEV
76. VOM-HAQ
77. FAX-QUD
78. CEG-RUH
79. KOR-WUY
80. ZEP-BUW
81. KER-BIH
82. GOP-NUY
83. BAJ-QOR
84. YUL-FAZ

BIBLIOGRAPHY

Books

Atkinson, R. C., G. H. Bower, and E. J. Crothers, An Introduction to Mathematical Learning Theory, New York, John Wiley & Sons, Inc., 1965.

Atkinson, R. C., and W. K. Estes, "Stimulus Sampling Theory," Vol. II of Handbook of Mathematical Psychology, edited by R. D. Luce, R. R. Bush, and E. Galanter (3 volumes), New York, John Wiley & Sons, Inc., 1963.

Ausbel, D. P., The Psychology of Meaningful Verbal Learning, New York, Grune & Stratton, 1963.

Deese, J., The Psychology of Learning, New York, McGraw-Hill Book Company, Inc., 1958.

Estes, W. K., "Learning Theory and the New 'Mental Chemistry'," Controversial Issues in Learning, edited by H. Goldstein, D. L. Krantz, and J. D. Rains, New York, Appleton-Century-Crofts, 1965.

__________, "The Statistical Approach to Learning Theory," Vol. II of Psychology: A Study of a Science, edited by S. Koch (7 volumes), New York, McGraw-Hill Book Company, Inc., 1959.

Guthrie, E. R., "Association by Contiguity," Vol. II of Psychology: A Study of a Science, edited by S. Koch (7 volumes), New York, McGraw-Hill Book Company, Inc., 1959.

__________, The Psychology of Learning, New York, Harper & Row, 1935.

Hays, W. L., Statistics for Psychologist, New York, Holt, Rinehart, & Winston, Inc., 1963.

Hilgard, E. R., "Methods and Procedures in the Study of Learning," Handbook of Experimental Psychology, edited by S. S. Stevens, New York, John Wiley & Sons, Inc., 1951.

_______________, *Theories of Learning* (Rev. ed.), New York, Appleton-Century-Crofts, Inc., 1956.

Hodgman, C. D., S. M. Selby, and R. C. Weast, editors, *C. R. C. Standard Mathematical Tables*, 12th ed., Cleveland, Chemical Rubber Publishing Company, 1959.

Hull, C. L., *A Behavior System*, New Haven, Yale University Press, 1952.

___________, *Essentials of Behavior*, New Haven, Yale University Press, 1951.

___________, *Principles of Behavior*, New York, D. Appleton-Century Company, Inc., 1943.

Kenney, J. F., and E. S. Keeping, Vol. I of *Mathematics of Statistics* (2 volumes), Princeton, D. Van Nostrand Company, Inc., 1954.

Kimble, G. A., *Hilgard and Marquis' Conditioning and Learning*, New York, Appleton-Century-Crofts, 1961.

Logan, F. A., "The Hull-Spence Approach," Vol. II of *Psychology: A Study of a Science*, edited by S. Koch (7 volumes), New York, McGraw-Hill Book Company, Inc., 1959.

Marx, M. H. and W. A. Hillix, *Systems and Theories in Psychology*, New York, McGraw-Hill Book Company, Inc., 1963.

McGeoch, J. A., and A. L. Irion, *The Psychology of Human Learning*, New York, Longmans, Green and Co., 1952.

McNemar, Q., *Psychological Statistics*, New York, John Wiley & Sons, Inc., 1962.

Restle, F., "Sources of Difficulty in Learning Paired Associates," *Studies in Mathematical Psychology*, edited by R. C. Atkinson, Stanford, Stanford University Press, 1964.

Spence, K. W., *Behavior Theory and Conditioning*, New Haven, Yale University Press, 1956.

Thorndike, E. L., *The Fundamentals of Learning*, New York, Teachers College, 1932.

Winer, B. J., *Statistical Principles in Experimental Design*, New York, McGraw-Hill Book Company, Inc., 1962.

Wolman, B. B., *Contemporary Theories and Systems in Psychology*, New York, Harper & Brothers, 1960.

Articles

Clark, L. L., T. G. Lansford, and K. M. Dallenbach, Repetition and Associative Learning," *The American Journal of Psychology*, LXXIII (1960), 22-40.

Estes, W. K., "All-or-None Processes in Learning and Retention," *The American Psychologist*, XIX (1964), 16-25.

Estes, W. K., B. L. Hopkins, and E. J. Crothers, "All-or-None and Conservation Effects in the Learning and Retention of Paired Associates," *The Journal of Experimental Psychology*, LX (1960), 329-339.

Jensen, A. R., "Serial Rote-Learning: Incremental or All-or-None?" *Quarterly Journal of Experimental Psychology*, XV (1963), 27-35.

Krechevsky, I. A., "A Study of the Continuity of the Problem-Solving Process," *Psychological Revue*, XL (1938), 107-133.

Kristofferson, A. B., "Repetition and Paired-Associates Learning," *Science*, CXXXIV (1961), 2036-2037.

Lockhead, G. R., "A Re-evaluation of One-Trial Associative Learning," *The American Journal of Psychology*, LXXIV (1961), 590-596.

Postman, L., "Repetition and Paired-Associate Learning," *The American Journal of Psychology*, LXXV (1962), 372-389.

Reed, J. C., and W. D. Riach, "The Role of Repetition and Set in Paired-Associate Learning," *The American Journal of Psychology*, LXXIII (1960), 608-611.

Reynolds, J. H., "Repetition Factors in One Trial Learning of Paired Associates," *The Journal of Experimental Psychology*, LXV (1963), 362-367

Rock, I., "The Role of Repetition in Associative Learning," *The American Journal of Psychology*, LXX (1957), 186-193.

Rock, I., and W. Heimer, "Further Evidence of One-Trial Associative Learning," The American Journal of Psychology, LXXII (1959), 1-16.

Rock, I., and G. Steinfield, "Methodological Questions in the Study of One-Trial Learning," Science, CXL (1963), 822-824.

Schwartz, Marian, "Transfer from Failed Pairs as a Test of One-Trial vs. Incremental Learning," The American Journal of Psychology, LXXVI (1963), 266-273.

Seidel, R. J., "Role of Repetition and Reinforcement in Learning," Psychological Reports, XIII (1963), 823-828.

Spence, K. W., "An Experimental Test of the Continuity and Non-Continuity Theories of Discrimination Learning," The Journal of Experimental Psychology, XXXV (1945), 253-266.

Underwood, B. J., and G. Keppel, "One-Trial Learning?" Journal of Verbal Learning and Verbal Behavior, I (1962), 1-13.

Underwood, B. J., R. Rehula, and G. Keppel, "Item-Selection in Paired Associate Learning," The American Journal of Psychology, LXXV (1962), 353-371.

Voeks, Virginia W., "Formalization and Clarification of a Theory of Learning," The Journal of Psychology, XXX (1950), 311-322.

Williams, Joanna P., "A Test of the All-or-None Hypothesis for Verbal Learning," The Journal of Experimental Psychology, LXIV (1962), 158-165.

__________________, "Supplementary Report: A Selection Artifact in Rock's Study of the Role of Repetition," The Journal of Experimental Psychology, LXII (1961).

Wogan, M., and R. H. Waters, "The Role of Repetition in Learning," The American Journal of Psychology, LXXII (1959), 612-613.

Wollen, K. A., "One-Trial Versus Incremental Paired-Associate Learning," Journal of Verbal Learning and Verbal Behavior, I (1962), 14-21.