SINGLE TRIAL LEARNING OF PAIRED ASSOCIATES

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CHAPTER I

THE PROBLEM

Statement of the Problem

Traditionally, learning was assumed to be a gradual acquisition process. This accepted position naturally stems from the utilization of the learning curve to express the relation between response strength and practice.

Ebbinghaus (1913) in his classic work on memory suggested the curve of his retention was roughly logarithmic in form. In the thirties of the current century Thurstone (1930) derived an empirical curve that proved very successful in predicting maze learning behavior in rats. Hull's (1943) hypothetico-deductive system formalizes to a greater extent this incremental function of the acquisition process, initiated by Ebbinghaus and Thurstone. Hull's theory of response evocation states that the parameter reflecting probability of response, reaction potential (S^ER), increases as a function of the number of reinforced trials and absence of the response on a given trial may be attributed to the parameter of oscillation. While it is possible to advocate a theory of single trial learning, acceptance of the learning curve as an embodiment of the assumption that repetition and reinforcement increases associative strength in a gradual manner prompted Kimble (1961) to take the position

that the burden of proof must be assumed by the advocates of such a theory.

In general, associationistic learning theorists have endorsed the incremental approach to learning while field and cognitive theorists have depreciated the role of practice, repetition, and experience. The noncontinuity approach considers the incremental nature of the learning curve to be a function of the traditional analysis and experimentation in learning. For instance, practice in Guthrie's system merely provides more opportunity for additional stimulus elements or cues to be either alienated or assimilated while his central law of learning is, "A combination of stimuli which has accompanied a movement will on its recurrence tend to be followed by that movement" (Guthrie, 1952; p. 23). Estes (1960) in discussing the popularity and wide acceptance in contemporary psychology of associative strength's being dependent upon the number of reinforced trials suggests that two recent empirical investigations cast doubt upon the incremental assumption: (1) Kimble's (1956) finding with eyelid conditioning that the nature of the learning curve was unaffected when the CS was omitted during a substantial block of trials and (2) the finding by Rock (1957) of no retardation in learning of paired associates when missed pairs were replaced by new pairs, thus depriving Ss of the advantage of practice.

Other theorists who have advocated a noncontinuity approach to acquisition include Voeks (1954), Sheffield (1949), and Krechevsky (1932).

General Hypothesis

In general, it is suggested that though a learning of paired associates may occur either incrementally or in a single trial, the probability that single trial or incremental learning will occur is a function of the age of subject, capacity of subject, and nature of the stimulus material. The role of practice or repetition may be masked in the presence of increased levels of the other factors and the more this tends to happen the more learning appears to be of the single trial variety.

Implications

Although the tenor of the general hypothesis of this research suggests that the phenomenon of single trial learning, as suggested by Rock, is artifactual, nevertheless, the issue is a central one and the implications warrant exhaustive examination of the single trial proposition. If the results of the laboratory can support the proposition that learning in its elemental association is an all-or-none connection, then the analogy of the digital computer as a model of the human brain is certainly strengthened and the implications for the neurology of learning are on a more solid empirical ground. Though the educational curricular implications of the validity of single trial learning are more obscure, they certainly should not be overlooked.

There are implications for the independent variables of age, achievement, and meaningfulness included in the present

research. In his review of the area of developmental psychology, Stone (1961) alludes to the importance of investigating the possibility of single trial learning over a substantial age range. Inclusion of three levels of meaningfulness is an attempt to relate associative value scales to learning performance measures.

Terms

Conventional terminology utilized in paired associate learning will be observed in this paper. When referring to a particular pair, the stimulus element is the left hand member of the pair and the response element is the right hand member. In conventional paired associate learning methodology, the set or list of pairs is presented sequentially during the learning trial and, following some shuffling, is presented for testing recall by having only the stimulus element shown. The task of the S is to anticipate the appropriate response element. Several measures of paired associate learning performance are used: number of trials required to reach some criterion of mastery, total number of incorrect responses in reaching a criterion of mastery, and mean number of correct responses per trial.

The essential modification made by Rock to support his single trial learning hypothesis is the deletion of the pair missed on a test trial and substitution of a new pair for the missed pair. This experimental treatment has been referred to by numerous terms in the literature: experimental

(Rock, 1957; Rock and Heimer, 1959; Clark, Lansford and Dallenbach, 1960; Wogan and Waters, 1959), drop-out (Underwood, Rehula and Keppel, 1962), substitution (Carron, 1960), replacement (Lockhead, 1961). In this paper the main experimental treatment will be called single trial learning condition (STL).

Notation will follow the format prescribed by the American Psychological Association throughout this paper. The convention of abbreviating subject (S) and experimenter (E) will be observed.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction: Single Trial vs. Repetition Learning

Among the enduring questions in the history of psychology is the nature of the acquisition process in learning. There are two aspects of this question: (1) what is it that becomes associated and under what conditions of reinforcement, and (2) does the connection occur in a single trial or is it gradually acquired as a consequence of practice (Spence, 1951)? This latter consideration, the focus of this paper, has undergone an interesting alteration over the past few decades. In the literature contrasting single trial learning with incremental learning, the animal learning a maze has been replaced by the college sophomore's learning verbal material. Underwood and Keppel (1962) consider this a momentous event, observing,

> Controversies are not new in interpretations of learning phenomena, but it is a signal historical event when the controversies are based primarily on the interpretation of data from the verbal learning laboratory rather than on data from the animal-learning laboratory. The history of verbal learning shows few instances in which the learning of a list of nonsense syllables became the center of affectively tinged and opposed conceptual assertions. (p.1)

In the summary of the same article, Underwood concludes,

> Not since Thorndike has the human subject been used consistently as a source of data to test basic

> theoretical notions about learning. The memory drum seems to have replaced the T-maze, at least temporarily. This may or may not be an appropriate trend (p. 12).

After a brief look at two recent methodological procedures contrasting single trial learning with incremental learning utilizing human subjects, attention will be focused on Rock's original experiments. Estes (1960) found that if the stimulus element is paired with two different response elements the same number of times, performance on a series of test trials more readily fits a single trial hypothesis than an incremental hypothesis because Ss tend to favor the recall of either one response element or the other rather than yielding the expected probability of recalling both. In a less well known experiment Murdock (1960) presented Ss with numerous lists of words with only one of the words repeated and found the probability of recall for the repeated words exceeded, but not significantly so, the probability of recall for the words presented but once. Murdock concluded that since the probability of recall did not differ significantly for repeated and nonrepeated words, repetition was to no avail.

Rock's Paradigm

The experiments of Rock (1957) and Rock and Heimer (1959) were designed to support the hypothesis that, in learning paired associates, the associations are formed on a single trial, and previous experience with a pair, prior to the trial on which it is learned, does not seem to be of any

value. In Rock's initial study the paired associate material consisted of lists of twelve letter-number pairs, the stimulus element being a letter or double letter and the response element being a number. A metronome was used to time a three second exposure of each pair and a five second interval separated successive cards. Ss in the repetition group were instructed to associate the letter or double letters on each card with the number and were told that the serial order would be changed randomly. The single trial Ss were also told that new pairs would appear from time to time and it was their task to learn the pairs shown. The presentation of all twelve pairs constituted the learning trial and was followed immediately by the test trial in which the S was presented the stimulus letter or double letter alone and required to give the appropriate number. In his initial study Rock does not disclose the length of time between the learning trial and the test trial, but states that it followed the learning trial after shuffling. During the test trial the stimulus elements were presented at the rate of one every five seconds. During the thirty second interval which intervened between test trial and the subsequent learning trial, E substituted new pairs for the pairs missed by single trial Ss.

In summary, the single trial group differed from the repetition group in that pairs missed on a given learning trial were eliminated and a new pair substituted in the subsequent learning trial.

In all, there have been twenty-four separate experiments reported in eleven different publications relevant to the line of research initiated by Rock (1957). It is possible to tally the outcome of these experiments as being favorable or unfavorable to Rock's single trial hypothesis. This compilation must be offered with reservations. First, as Underwood points out (Underwood and Keppel, 1960) to consider an experiment as supporting Rock's hypothesis, one must fail to reject the null hypothesis. Therefore, whether a positive instance represent the single trial phenomenon or E's using a small number of Ss who vary widely from individual to individual, is highly speculative. Nevertheless, for an experiment to be considered as supportive of Rock's hypothesis, no significant difference must be found between the single trial group and the repetition group, or the single trial group must exceed the repetition group in performance. Secondly, some investigators performed many experiments, and the division of positive and negative instances was not equal within publications. For example, Rock ran six studies and supported his conclusions on five of them (Rock, 1957 and Rock and Heimer, 1959), while Underwood performed five studies with four of them failing to support Rock. Third, sample size varied extensively, some studies utilizing several times as many Ss as other studies used. Fourth, it is hard to view each experiment as a separate entity; each must be viewed within the context of the E's purpose. Some experiments replicated Rock's original

study in order to show how Rock's results were artifactual because the manipulation of a crucial variable would change the results from positive to negative (e.g., Lockhead, 1961). Finally, although all experiments used a college population, type of stimulus material and intertrial intervals were not constant over experiments. It is of interest, nevertheless, to note that thirteen of the twenty-four reported experiments could be interpreted as supporting the single trial hypothesis, while eleven found differences that favored the repetition group. About half of the Es concluded that their studies successfully replicated Rock even though some are reluctant to accept the single trial learning hypothesis (Rock, 1957; Rock and Heimer, 1959; Wogan and Waters, 1959; Clark, Lansford and Dallenbach, 1960; Johnson and Meenes, 1959). The other half report their findings as incompatible with Rock's single trial hypothesis (Reed and Riach, 1960; Underwood and Keppel, 1962; Carron, 1960; Lockhead, 1961; Postman, 1962; Schwartz, 1963). Most of this latter group do not feel that their work negates the possibility that learning could occur on a single trial, but, while recognizing the possibility of single trial learning they feel that the work of Rock does not eliminate an incremental interpretation of the results.

Methodology

All studies reported in the literature used a college population, either graduate or undergraduate. Sex is not regarded as a significant variable; Es usually balanced the

male-female ratio in the single trial group with that of the repetition group.

Rock (1957) provided a cursory description of his apparatus in the original study, mentioning only the type of stimulus material and the use of a metronome to time the exposure interval. In the later studies (Rock and Heimer, 1959), the Es describe a system of envelopes which cover part of the 3 x 5 cards and facilitate interchanging stimulus and response elements in the first experiment of this series. The mechanical card changer used in the experiments by Clark, Lansford and Dallenbach (1959) has been described (Dallenbach, 1959). Underwood (1962) used a manual card changer for some of his studies. Wogan and Waters (1959) used a tachicron tachistoscope. In summary, Es either used card holders, mechanical card changers or tachistoscopes to presat the stimulus material. Where manual presentation occurred, timing of presentation was accomplished by use of metronomes. Apparatus by itself seems an irrelevant factor in these experiments. It becomes important only because length of exposure and inter-exposure interval are mechanical properties of the apparatus.

Although details of apparatus may be largely ignored, methodological procedure followed in Rock-like experiments are most controversial. The procedural criticisms leveled against Rock are (1) item selection provides the single trial group with an easier list, (2) intralist competition makes the task more difficult for the repetition group, (3) time

interval between stimulus pair exposures permits rehearsal, (4) Ss fail to differ because both groups utilize mnenomic devices, (5) instructional set favors the single trial learning Ss and (6) this procedure represents merely one aspect of the associative learning process.

Underwood states the first two objections quite succinctly:

> The obvious question to raise concerning the procedures followed throughout the above mentioned studies in which letter-number pairs were used is whether the insertion of new pairs for the experimental /single trial/ Ss may not have produced a factor or factors which facilitated learning (Underwood, Rehula and Keppel, 1962; p. 355).

The item selection possibility is recognized by most investigators and, stated simply, suggests the items substituted for the missed items are easier than the ones that are eliminated.

Item selection: Rock himself was aware of the item selection possibility and designed an experiment to meet this objection (Rock and Heimer, 1959). Two digit number pairs unlearned after one presentation were pitted against pairs that were still unlearned after four presentations. Rock reasoned that if Ss normally learn the easiest third of a seven item list on one trial and the easiest third of a twelve item list on four trials, then if an additional test trial is given with four of the unlearned items on the short list (seven pairs) mixed with four of the unlearned items on the long list (twelve pairs), the Ss are attempting to recall equally difficult material. It was further argued that

items from the long list should be more readily recalled if repetition works to the Ss advantage, since the Ss has had previous experience with these pairs. The results slightly favored the recall of the pairs from the long list. The nonsignificance of this difference, however, was interpreted as confirming the single trial hypothesis and a replication of this experiment showed no difference between the mean number of pairs correct on the critical test trial. According to Rock, eliminating the learned pairs constitutes an operational definition of "easiness" and therefore the unlearned items in both the long and the short list are equated in difficulty:

> This experiment is particularly important because it does not contain any of the possible flaws mentioned at the beginning of the paper . . . , the technique is a sensitive one and the objection concerning the difficulty of unlearned pairs has been met (Rock and Heimer, 1959; p. 11).

Clark, Lansford and Dallenbach (1959) found no communality among Ss regarding the pairs that were easy or difficult to learn, i.e., neither early learning in the case of the repetition Ss nor single presentation in the case of the single trial Ss clustered around certain pairs, and learning or not learning was spread widely throughout the pairs in the stimulus pool. Clark, Lansford and Dallenbach (1959) also performed an experiment similar to that of Rock and Heimer (1959) in which difficulty was operationalized as failure to learn on any given trial for the single trial learning group. No significant differences were found upon relearning the difficult pairs. "This means that there are no objective

differences among our stimulus pairs in ease or difficulty of learning but it does not eliminate the subjective or idiosyncratic differences that may exist among them" (Clark, Lansford and Dallenbach, 1959; p. 26).

Postman (1962) objects to the use of the final experiment in the Rock and Heimer series (1959) as a critical and unequivocal proof of single trial learning on several grounds. First, the lengths of the lists differed and the rate of learning varies inversely with the length of the list: "One certainly cannot compensate for the length-difficulty relationship by a difference in the number of trials and then treat this same difference as the independent variable in assessing the effects of repetition on items said to be of equal difficulty" (Postman, 1962; p. 374). In other words, although you can say that unlearned words are more difficult than learned ones, you cannot consider ones unlearned after only one trial equally difficult with those still not learned after four trials. The finding of no significant difference may equally reflect the greater difficulty of those pairs still not learned after three trials just as readily as the lack of effect of repetition. Second, intraserial interference and opportunity to rehearse differed for long and short lists. Third, the long list was learned after the short one, thus the effects of proactive and retroactive inhibition are not known. Finally, since large numbers of Ss were excluded because they either did not learn enough or they learned too many pairs, the generality of the findings are greatly restricted.

In a more recent publication, Postman (1963) states that the research of Underwood, Rehula, and Keppel (1962) and Postman (1962) unequivocally demonstrates item selection as a methodological flaw in the work of Rock, basing this conclusion on three findings. First, Underwood constructed lists containing both high associative valued bigrams (go) and low associative valued bigrams (xv) and found the final list learned by the single trial learning group contained more high associative bigrams than low associative ones. Secondly, when a second control group (repetition) which learned the final list mastered by the single trial group was introduced, differences were found between this second control and the first control that simply learned a list randomly selected from the stimulus pool by the repetition method. Finally, random selection of lists produced lists of unequal difficulty, and item selection favored or handicapped the single trial learning group, depending on list difficulty. The above objections led Postman to conclude, "This analysis leaves no doubt but that the drop-out [single trial] procedure introduces a significant amount of item selection . . . . Our final evaluation of Rock's studies brings us back to the status quo ante. The facts are consistent with both interpretations" (Postman, 1963; p. 304).

In summary, the findings regarding the existence and/or biasing effect of item selection in Rock's paradigm depends upon method of attack:

1. Frequency distributions of pairs learned by single trial learning Ss and pairs learned on first trial by repetition Ss fail to show clustering around particular pairs (Clark, Lansford and Dallenbach, 1959).

2. Operationalizing difficulty as pairs not learned after any given number of trials fails to show differences in learning of items unlearned after one trial opposed to items still unlearned after many trials (Rock and Heimer, 1959; Clark, Lansford and Dallenbach, 1959).

3. When preselected pairs of diverse associative value are used, the list learned by the single trial learning group contains more high associative value pairs (Underwood, Rehula and Keppel, 1962).

4. An additional control group that learns the list mastered by the single trial learning group by the repetition method often shows differences between the control groups (Underwood, Rehula and Keppel, 1962; Postman, 1962).

5. A ratio of the number of times a pair appears on lists learned by single trial learning Ss over the number of times it was presented to single trial learning Ss produces an item selection ratio for each stimulus pair. The item selection ratios for several experiments are found to intercorrelate significantly (Underwood, Rehula and Keppel, 1962).

6. Moderate correlations are found between selection ratio and rated difficulty of pairs (Underwood, Rehula and Keppel, 1962).

The findings clearly conflict. The heterogeneity of stimulus difficulty appears to be a crucial factor. When highly difficult material is contrasted with easy material, selection is apparent.

Task difficulty: The second criticism of Rock's experiment (1957) argues that failure to find differences between the single trial learning group and the repetition group may be due to the more difficult task created for the repetition group. The former criticism attributes the lack of difference to the method providing an easier task for the single trial learning group. This criticism argues that when a Ss forms an incorrect association, he forms a bond that competes with his learning the correct association and therefore any lack of difference between single trial learning group Ss and repetition Ss is not due to the absence of repetition but to the presence of these partially formed associations which must be overcome.

Rock was aware of this possibility and the first experiment in the second series (Rock and Heimer, 1959) was designed to meet this objection. Rock used lists of eight syllable-syllable pairs but had material so arranged that pairs missed by a S in the single trial group would appear in different combinations. For example, a S may miss two pairs on one given trial: TUP-NOZ and QUZ-FIM. The list on a subsequent learning trial may contain the recombined pairs: TUP-FIM and QUZ-NOZ. Thus if the S partially forms an association during the previous trial, it would interfere with his learning the

new pair in much the same way that it would for the repetition group because the wrong association would have to be overcome. In Rock and Heimer's experiment the single trial learning group learned in fewer trials than the repetition group, although the difference was negligible. This finding was interpreted as compatible with the single trial hypothesis.

Postman (1962) disagrees with Rock (1957) on the interpretation of this experiment. Rock (1957) accepts the results as additional evidence of single trial learning, although he admits the single trial learning Ss had the advantage of easier items: "In some cases the pairs resulting from interchanging for the experimental [single trial learning] group were unquestionably easier to learn. . . . Such pairs were, however, exceptional" (Rock and Heimer, 1959; p. 5). He feels that this advantage is more than counterbalanced by the advantage of the repetition group; a stringent response measure such as a recall measure penalizes the single trial learning group by requiring the elimination of missed pairs even though they were learned earlier, and thus associations formed at a subthreshold level would facilitate the subsequent consolidation of the connection for the repetition group.

Postman (1962) rejects this point of view, claiming it is insufficient and inappropriate to equate intuitively the biasing effect of such factors as item selection and rehearsal with subthreshold associations.

Clark, Lansford and Dallenbach (1959) after replicating Rock's experiment, performed an experiment in which the

unlearned pairs in the single trial learning condition were later relearned by the repetition method. A control group was presented a list once to derive a list comparable to that of the single trial learning groups. The Es felt the evidence for associative interference was impressive: (1) though there was no difference between the single trial learning and the repetition group on the first test trial, on subsequent trials the repetition group made almost twice as many errors; (2) on the trial before complete mastery of the list, repetition Ss made twice the errors made by single trial learning Ss; (3) repetition Ss made twice the reversals (missing a pair that was previously correct) made by the single trial learning Ss; (4) variance was almost twice as large for the repetition group; (5) when single trial learning Ss relearned by the reptition method "difficult" pairs (pairs eliminated because they were missed during the early part of the experiment) were learned as readily as control Ss learned "easy" items (pairs randomly selected from the item pool); (6) interference was only present when the repetition condition was involved; (7) errors did not cluster around specific pairs. These findings led Clark, Lansford and Dallenbach (1959) to conclude that associative interference inhibits the learning of certain pairs, and their removal facilitates learning and associative interference is not equivalent to item difficulty.

Underwood, Rehula and Keppel (1962), on the other hand, rejected the associative interference interpretation in

favor of the item selection hypothesis. A control group that learned the final lists mastered by the single trial learning group learned it in significantly fewer trials when learning was by the repetition method. Therefore, they (Underwood, Rehula and Keppel, 1962) argue, it was not the interference but the item selection that accounts for Rock's (1957) results.

Numerous studies report greater variance for the repetition group when trials to criterion is used as a dependent variable (Clark, Lansford and Dallenbach, 1959; Lockhead, 1961; Rock, 1957; Rock and Heimer, 1959). One possible explanation for the greater variance of the repetition group is to assume that associative interference is responsible. Practice, it could be argued, reduces the mean trials to criterion though not influencing the variance, while associative interference increases both the mean and the variance. The result of the oppositional effect of practice and associative interference on the repetition group is that the mean is increased sufficiently to be equivalent to that of the single trial learning group while the variance of the repetition group remains larger than that of the single trial learning group. This speculative analysis requires three reservations: (1) with one exception (Experiment IV: Clark, Lansford and Dallenbach, 1959) the difference between the two variances are slight, comfortably within the homogeneity of variance assumption for statistical comparison of means; (2) in many experiments the variances

are not reported (Carron, 1960; Postman, 1962; Underwood, Rehula and Keppel, 1962; Wogan and Waters, 1959) with the safest assumption being differences are nonexistent or negligible; and (3) this tendency exists only for the dependent variable of trials to criterion and there are two exceptions even when using this measure (Experiment IIA: Underwood, Rehula and Keppel, 1962; Reed and Riach, 1960).

Instructional set: The lack of difference between the single trial group and the repetition group may be attributed to the differential instructions given. Since the single trail group had new pairs introduced, some Es (Rock, 1957; Clark, Lansford and Dallenbach, 1957) instructed these Ss not only to anticipate the new pairs but also to Attempt to learn them:

> In view of the procedure used with the experimental /single trial learning/ group, S was told in advance that new pairs might be shown from trial to trial, although the total number would remain the same, and that it would be his task to try to learn all those shown at any time (Rock, 1957; p. 187).

In their followup study, Rock and Heimer (1959) did not mention whether or not they differentially instructed their Ss. Other investigators fail to mention the specific content of their instructions or whether they instructed single trial learning and repetition groups differentially (Lockhead, 1961; Wogan and Waters, 1959).

Reed and Riach (1960) are the only investigators sufficiently convinced of the relevance of instructional set to incorporate it into their experimental design. They argue that the set to associate, rather than to learn acts as a

hindrance on the performance of the repetition group. They utilized a 2 x 2 factorial arrangement with single trial learning vs. repetition learning and set to associate vs. set to learn as the two experimental treatments. Instructions to learn are probably more forcibly stated than in the other experiments of this paradigm: "Learn as many of the combinations as you can in each trial. . . . Remember, your task is to learn as many of the pairs as you can on any trial" (Reed and Riach, 1960; p. 609). The findings of this experiment are ambiguous, since the main effect for differential instructional set was in the right direction but did not attain significance when the dependent variable was total errors, though trials to criterion yielded a significant F for instructional set.

The only other investigator reporting differential instruction of single trial learning and repetition groups is Clark, Lansford and Dallenbach (1959) but they told the repetition group that they would be tested after the learning trial. The single trial learning group was told that new cards would be introduced and that they should learn the cards shown.

The weight of evidence supporting the instructional set criticism is inconclusive. Other than the limited, though direct, support of Reed and Riach (1960), the only other support is indirect. Such indirect support is found in the fact that instructions to "associate" happen to coincide with some successful tests (Rock, 1957; Clark, Lansford and Dallenbach, 1959) and instructions to "learn" coincide with

some unsuccessful tests (Postman, 1962; Underwood, Rehula and Keppel, 1962) of the hypothesis that single trial learning is equivalent to repetitious learning. The fragmentary and indirect evidence supporting instructional set as a critical variable suggests a negligible role for instructional set in experiments investigating single trial learning thus far.

Mnemonic devices: It has been suggested that mnemonic devices, used by Ss in paired associate learning, render Rock's (1957) paradigm an inappropriate test of the single trial learning hypothesis since the use of mnemonic devices is likely to result in single trial learning, whether on the first trial or after a series of trials. Clark, Lansford and Dallenbach (1959), the main proponents of this criticism, schematized the use of mnemonic devices as involving an intermediary, c, to facilitate the connection of a to b, thus a→c→b symbolizes the process of paired associate learning. The process involves two stages: (1) the development of a device, and (2) the retention of the device. Ss reported that intertrial intervals were spent rehearsing, not the pairs, but the connecting device which obviously relates this criticism to the amount of rehearsal time. This relationship of exposure time to use of mnemonics should manifest itself when tactics are used to eliminate mnemonics, i. e., shortening the exposure times and the intertrial interval (Lockhead, 1961; Clark, Lansford and Dallenbach, 1959; Underwood, Rehula and Keppel, 1962). When Clark, Lansford and Dallenbach (1959) shortened the interval, only a small fraction of the Ss reported

using the devices. Nevertheless, single trial learning Ss learned faster. The Es write,

> The results of Experiment III take us back to where we were before Experiment II was undertaken, but with this difference: we know that mnemonics are not responsible for Rock's results (Clark, Lansford and Dallenbach, 1959; p. 37).

Postman (1962) criticizes these studies because E does not control what Ss do during the learning trials. It is possible for the S to ignore most of the list, according to Postman, and concentrate on a few pairs each trial, learning them with or without mnemonics. Postman feels a more adequate control for both mnemonics and rehearsal is to have the S read aloud the pairs as they are presented in the learning phase. Under these conditions, Postman (1962) found significantly more Ss reaching criterion of one perfect recitation and more correct anticipations per trial in the repetition groups.

A bit of indirect evidence can be found in Underwood's (1962) experiments. He had Ss recite the stimulus material during the learning trials in some experiments but not in other experiments. Underwood performed an analysis of variance with experiments as a factor and found a nonsignificant F. If recitation had had a marked effect on single trial learning, it should have influenced the above mentioned analysis of variance.

Rock's (1957) methodology has been criticized for the liberal amount of rehearsal time associated with experimental procedure. It is argued that no differences between the

single trial and the repetition group are found because there is sufficient time for both groups to practice and therefore the single trial group is really another repetition group.

In Rock's original study a new stimulus would appear every eight seconds during the learning trials. The stimulus-response pair would be visible for three seconds followed by a five second pause. During the testing trials the S had five seconds in which to respond before the next stimulus element was presented. A thirty second interval separated the test trial and the next learning trial. This comparatively long period of time has been the subject of criticism directly or indirectly (Clark, Lansford and Dallenbach, 1959; Postman, 1962; Underwood, Rehula and Keppel, 1962; Lockhead, 1961; Carron, 1960).

When Lockhead (1961) shortened the exposure time to .75 seconds with 1.25 seconds inter-exposure interval, the single trial group took almost twice as long to reach criterion. Clark, Lansford and Dallenbach (1959), on the other hand, found the single trial group took significantly less time to learn when the exposure time was reduced to one second and the inter-exposure interval was eliminated. Underwood, Rehula and Keppel (1962) eliminated the inter-exposure interval and found essentially what had been found in his earlier experiments; the single trial learning group was inferior to his two control groups. In the next experiment he shortened the interval from three seconds to two seconds.

The only change, other than increasing the number of trials to reach criteria for all Ss, was a slight tendency to decrease the difference between the single trial learning group and the control groups. The difference between the single trial learning group and the repetition group did not quite reach significance. In other words, shortening the interval had the effect of tending to make the results more compatible with Rock's "no difference" findings. Carron (1960) eliminated the inter-exposure interval and had Ss do subtraction problems between learning and test trials. He found that the repetition group made significantly fewer errors.

To summarize, the results conflict. Reducing the available rehearsal time tended to improve performance in the single trial group (Clark, Lansford and Dallenbach, 1959), to improve performance in the repetition group (Lockhead, 1961) and to make a negative finding less negative (Underwood, Rehula and Keppel, 1962).

Associative meaning: The final procedural criticism suggests that the work of Rock merely pertains to part of the paired associative learning process. Learning paired associates involves two stages--the response learning stage and the association or hook-up stage. Critics (Underwood, Rehula and Keppel, 1962; Postman, 1962; Postman, 1963) point out that Rock's focus is on the associative stage. This is not really a damaging criticism and Rock (1957) is aware of the scope of his research. In discussing familiarity of stimulus material he asserts, "Since one does not have to

learn the items as such if they are familiar, one can concentrate on the associations to be formed" (p. 188). Rock suggests a two stage model of mastering paired associates: (1) a few pairs are learned in single trial fashion, and (2) formed associations are strengthened upon subsequent repetition and additional opportunity is provided for new associations to be formed. Postman (1963) feels the distinction, ". . . appears plausible but it greatly complicates the theoretical picture." This changes Rock's hypothesis from an all-or-none to a some-or-none and Postman queried, "How much is some" (p. 297)?

One very promising mathematical synthesis of this dilemma has been offered by Kintsch (1963) who theorizes that learning occurs in a single trial in both the response learning stage and the association formation stage. His Markov Model predicts impairment of learning under single trial learning conditions since responses learned in one trial but not used are not available for hooking up on the subsequent trial. His data on twenty-three Ss confirms nicely the predicted functions for both the single trial group and the repetition group.

Summary: Concerning procedural criticism of Rock, the following conclusions seem in order:

1. With quite heterogeneous stimulus material, the single trial group does select items that are easier to learn. With quite homogeneous stimulus material, item selection is undetectable. Finally, the point along the

heterogeneity-homogeneity continuum where the transition from item selection to no item selection becomes apparent is unknown and shrouded in controversy.

2. It is possible that associative interference inflates the variance of the repetition group, although this distortion is not large enough to violate the homogeneity of variance assumption and only applies when trials to criterion is used as the dependent variable.

3. Instructions, although always a potential source of bias, have not been shown to be a critical variable in the research using Rock's paradigm.

4. The use of mnemonics is dependent, at least in part, upon the available exposure time and length of intervals between exposures. Elimination of inter-exposure interval and reduction of the amount of stimulus exposure time minimizes the use of mnemonic devices.

5. Rock's concept of single trial learning deals with the final or associative stage of paired associate learning and largely ignores the response learning stage. It is further recognized that single trial learning, as viewed by Rock, is not a molar conceptionalization and any theoretical extensions must incorporate additional variables.

Independent Variables

The independent variables of age, achievement, and meaningfulness, of central concern in this investigation, have received little attention in previous experimentation in

single trial learning.

Age: In general, age has not been used as a variable in single trial learning. The studies dealing directly with single trial learning have used college students for Ss. Lately, there has been a renewed interest in the learning of paired associates at different age levels (Palermo and Lipsit, 1963; Castaneda, 1961; McCullers, 1961) though not directly related to single trial learning. In this study, grade level is used instead of age.

Achievement: In the (Rock, 1957) original experiment, Rock found that the single trial group's average first-trial performance exceeded that of the repetition group after about three-fourths of the Ss had been assigned to experimental conditions. Subsequent S assignment was made on the basis of first trial performance resulting in almost identical average first-trial performance for both groups. This is the only attempt to control for Ss learning ability in all of the experiments following Rock's paradigm. Apparently the correlation between initial trial performance and other response measures is felt to be negligible.

Meaningfulness: The research that has been done using Rock's paradigm does not allow unequivocal interpretation of the role of meaningfulness of the stimulus material in single trial learning. One can rank the type of stimulus material utilized in previous research according to meaningfulness by operationalizing meaningfulness as associative value or familiarity (Noble, 1961). However, when one attempts

to relate this hierarchy of meaningfulness to whether or not the E replicated Rock's findings, no definitive pattern emerges. The most meaningful class would be the number-number pairs with both the stimulus and response elements being numbers. Rock and Heimer (1959) were the only ones to use this material and to successfully replicate Rock's original study. Rock and Heimer (1959) were the only Es to use first name pairs which would rank next in meaningfulness. The first experiment failed to replicate but a second which controlled for reminiscence reported successful replication. Third in the order of meaningfulness is the letter-number pairs. These pairs were the stimulus material used in Rock's original study (1957) and were used in five experiments: three positive (Clark, Lansford and Dallenbach, 1959; Rock, 1957; Wogan and Waters, 1959), and two negative (Reed and Riach, 1960; Underwood, Rehula and Keppel, 1962). Two negative studies are reported using nonsense syllables as the stimulus. One used nonsense syllable-number pairs (Kintsch, 1963) while the other used nonsense syllable-bigraph pairs (Underwood, Rehula and Keppel, 1962). Finally, with the nonsense syllable-nonsense syllable pairs, the least meaningful, two studies report positive results (Rock, 1957; Rock and Heimar, 1959) and two studies report negative findings (Lockhead, 1961; Postman, 1962). If you discount the work of Rock (1957) and Rock and Heimer (1959), as Postman does on methodological grounds, failure to replicate Rock tends to be associated with less meaningful stimulus material.

CHAPTER III

SPECIFIC HYPOTHESES AND DESIGN

This chapter will include a statement of the specific hypotheses derived from the general hypothesis, a discussion of the experimental design used to evaluate the derived hypotheses and an elaboration of methods utilized in implementing the experimental design.

Hypotheses

The general hypothesis of this research is that the phenomenon of single trial learning (Rock, 1957) may or may not emerge depending upon various independent variables. It is hypothesized that these other variables are more critical than the methodological artifacts discussed in the review. The three variables selected are age of the S, achievement level of the S, and meaningfulness of the stimulus material. First, it is argued that the older the S the more capable he will be and the greater will be his apparent ability to learn in one trial. Secondly, the brighter the S the more capacity he has to profit from experience; thus brighter Ss should show a greater tendency to learn in one trial. And finally, the nature of the stimulus material itself should differentially affect performance. The more meaningful the material the more readily

it should be learned because greater meaningfulness is assumed to facilitate single trial learning more than low meaningfulness of material. This, this research predicts main-effect differences due to age, achievement, and meaningfulness plus significant interactions of these factors with the main effect of single trial learning vs. repetition learning.

The experimental design in this research assumes a fixed analysis of variance model with repeated measures. The model is fixed because the levels of each factor were predetermined. The age factor was operationalized by selecting alternate school grade levels from fourth grade through twelfth grade. The achievement factor was operationalized by selecting Ss from three achievement levels within each grade level. The achievement levels were established by dividing all the students in the grade into three groups, each containing approximately one-third of the students. An attempt was made to keep Ss at each achievement level as homogeneous as possible by eliminating both extremely high achievers and extremely low achievers, thus trying to select Ss closest in ability to the mid-point of each achievement level. Levels of meaningfulness were established by selecting nonsense syllables which clustered around the three preselected associative value percentage points. Ss were assigned randomly to the main experimental condition of single trial learning vs. repetition learning after the above mentioned preselection.

In this experiment the single trial learning sample

included Ss at every grade level and every achievement level within each grade, as did the sample that learned repetitiously. Meaningfulness is the repeated measure. That is, there is not a distinct group of Ss for each meaningfulness level; every S learned all three levels of meaningfulness. This type design has both advantages and disadvantages. Where available Ss are limited, as in this research where average class size was in the thirties, E can investigate the same number of factors with minimal number of Ss and the inter-subject variance is reduced. On the other hand, carryover and order in which the different material is learned affects performance, thus raising considerable statistical and interpretive problems (Gaito, 1958).

Since there seem to be some discrepant findings associated with the particular dependent variable utilized (Reed and Riach, 1960), it was decided to incorporate three response measures in this research: number of trials to criterion of one errorless trial, total errors accumulated in reaching criterion, and average errors per trial.

The experimental design operationalizes the proposed hypotheses by generating the following predictions concerning the analysis of variances:

1. Factor A (single trial learning vs. repetitious learning) will show no significant difference (null hypothesis).

2. Levels of factor B (age) will yield a significant F ratio and the nature of the incremental function associated with age will be negatively accelerated.

3. Factors A and B will significantly interact. That is to say, at younger ages Ss in the repetition group will exceed the single trial learning Ss in performance but with increasing age single trial learning Ss will match or better the performance of Ss learning repetitiously.

4. Levels of factor C (achievement) will significantly affect Ss' ability to learn paired associates and it is further predicted that the nature of the incremental function will be linear in form.

5. Factors A and C will significantly interact; thus low achievement Ss will learn more readily by repetition while higher achievement Ss will learn more under single trial conditions.

6. The levels of D (meaningfulness) will affect learning significantly and the nature of the incremental function will be linear.

7. Finally, factors A and D will significantly interact. When learning low meaningful material, repetition Ss will learn more efficiently than single trial learning Ss, while the reverse will be true when high meaningful material is used.

Population

The discussion of methodology shall describe the subject population and assignment of subjects to experimental conditions, the apparatus and stimulus material used, and the procedure followed in having subjects participate.

All Ss participating in this research were enrolled in

the fourth, sixth, eighth, tenth, and twelfth grades of the laboratory schools on the campus of Kansas State College of Pittsburg during the fall and spring of 1963-1964. The laboratory schools draw students from the immediate environs of the college which is largely a middle class residential district. Children of faculty members represent a sizable block of the student body.

Students in the elementary and secondary laboratory schools were assigned to experimental conditions via the procedure outlined below:

1. In order to obtain Ss at three levels of achievement students in the elementary grades were listed according to their composite grade placement level on the Iowa Test of Basic Skills and secondary students were listed according to their verbal intelligence quotient obtained on the Lorge-Thorndike Test of Intelligence. Only students for whom scores were available were considered in the student population. One exception had to be made to this stipulation for a fourth grade substitution. The California Achievement Test scores were available for this student who had been ill when the Iowa Test of Basic Skills was administered. Since the correlation between these two achievement tests was high (Pearson product moment correlation = .89 for the 16 fourth grade students) and the California scores of other Ss in the same achievement group were compatible with those of the new Ss for whom no Iowa scores were available, the substitution was made.

2. Within each grade, Ss were divided into three

groups of approximately the same size according to their respective scores.

3. All elementary students in the sample pool were alternately assigned to either the single trial learning or the repetition group. In about half the grades the highest achievement score was assigned to the single trial learning group and the second highest was then assigned to the repetition group, etc. Secondary students were assigned to experimental conditions in an analogous manner. Since there were more students in the secondary grades, students were listed by achievement score and sex before being assigned to one of three equally sized achievement groups. At all grade levels, four Ss were then selected from each achievement group to satisfy the following conditions:

a. Within an achievement group extremely deviant scores eliminated and students whose scores tended to cluster around the midpoint of each achievement group were selected as much as possible.

b. Mean achievement score of single trial learning Ss approximated that of the repetition group of Ss.

c. Wherever possible, half the participating Ss in each grade were male and the other half were female. If this was impossible (in sixth grade there were twenty-one boys and seven girls) the same proportion was observed for both the single trial learning group and the repetition group.

d. When a S failed to reach the criterion of one error-less test trial on any of the three lists, a substitute was selected from the achievement score listings so that the new S's achievement score was closest to that of the S failing to reach criterion. The substituted S automatically received all the experimental conditions of the S failing to reach criterion.

4. Since each S was to learn all three levels of meaningfulness material, the order in which he learned the list of pairs was important. One of the six possible orders for learning the three meaningfulness levels of nonsense syllables was assigned to each S with the restriction that all possible orders occurred twice in both the single trial and the repetition conditions. In other words, randomization of order to Ss within conditions consisted of randomly assigning one of the six orders to a S then randomly assigning one of the remaining five other possible orders to the next S, etc.

Equipment

The equipment used in this research included a viewing screen, the stimulus material, and the timing device. The plywood screen had a 21" by 36" base and was 28" tall. The screen could be placed on a table and provided an acceptable coverage for stimulus material not in use, scoring sheets, etc. The middle of the screen had a 2.5" by 4.5" viewing window where the stimulus material was displayed. The device

used to time the exposure of the stimulus cards was a controlled reader set between twenty and thirty exposures per minute. At this setting, the device emitted an audible click consistently every 2.9 seconds. The E used this click as a cue to change the stimulus card on the learning trials and allowed a S the interval between two clicks or 5.8 seconds to respond on testing trials. The timing device was either hidden or placed in some inconspicuous place with only the controlled reader attachment of the projector turned on.

Syllables for the stimulus elements of the paired associates were selected from the Krueger List in Underwood's "Associative or Meaningfulness Values for 1,937 nonsense syllables" Appendix (Underwood and Schulz, 1960). The paired associate material was prepared in the following manner:

1. A continuum of associativeness was assumed and three equi-distant percentage points were selected at twenty-five point intervals: low associative value at 45 per cent, middle associative value at 70 per cent and high associative value at 95 per cent.

2. It was initially planned to use syllable-syllable pairs in such a fashion that a list of 106 syllables at each associative value level were randomly selected with the additional criterion being that the mean and standard deviation of associative percentages were equivalent for all levels. The percentage value of associativeness of selected syllables ranged five percentage points above and below the predetermined level of associativeness; e.g., in the low

associative value list only syllables rated between 40 per cent and 50 per cent in associative value were included.

3. Preliminary testing indicated that syllable-syllable pairs would be too difficult for fourth grade students, especially those of low achievement. Therefore, syllable-letter or double-letter pairs were made for each associative level by randomly assigning letters or double letters to the syllables that clustered around the predetermined percentage points. Letters were not paired with syllables that contained the same letter. The experiment was over half completed before E realized an exception to this restriction had accidentally occurred with a high associative value pair (PUD-U).

4. The paired associates selected in the above manner were typed on three by five cards in capital letters with primary type. Preliminary testing of the experimental procedures led to the discovery that Ss could see through the white note cards so opaque colored cards were used. Meaningfulness was color-coded; high meaningfulness pairs were typed on blue cards, middle meaningfulness pairs were typed on green cards, and low meaningfulness pairs were typed on red cards.

Procedure

The procedure for having Ss participate in the experiment was similar for elementary and secondary students with a few salient differences. Since the elementary and

secondary schools were housed in separate plants, it was decided to run the elementary Ss first to avoid having to transport the experimental equipment more than was necessary. Preliminary conferences with the elementary principal and laboratory faculty resulted in scheduling the hour from 8:30 A.M. to 9:30 A.M. every morning as the time when Ss would participate individually. It was felt that this schedule would disrupt the instructional program least. Additional hours were allocated as the experiment progressed. With one exception (the final substitute in the fourth grade sample participated in an early morning session and again in an afternoon session) Ss never participated more than once a day and as much as possible Ss were run in rotation. Elementary Ss were sent to the experimental room upon the request of the E. Subsequent Ss were notified by the returning S.

In contrast to the recruitment procedure followed in the high school, elementary Ss had very little choice about participating. However, no pressure was exerted and they seemed eager to volunteer. One fourth grade hyperactive male constantly peered around the screen at the stimulus material, had difficulty remaining in his seat and misconstrued the task of the experiment. He assumed the performance measure of the experiment was cumulative correct responses and seemed to be satisfied with the rate at which he was scoring "points." This fourth grader, learning under single trial conditions, was eliminated as a

S after thirty-four trials. During the last seven trials he responded "No" to each of the three pairs that were being presented for the first time.

Recruitment of secondary students was more indirect. After Ss had been selected from the population, personally addressed letters (see Appendix A) were sent to the students requesting their cooperation. Students were to indicate their willingness or unwillingness to participate in the experiment by checking the appropriate blank on an attached form and returning it to the main office of the high school. Approximately two weeks after the distribution of the letter twenty of the twenty-eight students who had returned the form volunteered and eight refused. The E then personally interviewed students who had not responded and students who had indicated unwillingness to participate. The interview was informal and persuasive but not coercive. Most students said they either did not understand the extent of the commitment or were reluctant to give up the time so close to semester finals (seniors are permitted to take a limited amount of college course work for credit). These Ss were given additional explanation and their participation was scheduled to the individual S's convenience. All but two students volunteered to participate. Substitutes were drawn from student achievement lists in the manner used in elementary student substitution for these two unwilling students and subsequent Ss who failed to reach criterion in a reasonable

time limit. The mean experimental time for the twelve Ss who were eliminated was 49.67 minutes (SD = 10.6).

Conferences with the principal and the high school faculty involved yielded permission to excuse students from eighth grade core class in addition to having students participate during their daily library period. Seniors had to be scheduled individually since they are not required to remain in the building when not in class. Considerable liberty was taken with the sequence of running Ss since seniors often failed to keep appointments. When this occurred, E recruited an available eighth or tenth grader who was pre-selected to participate and was in the library at the time.

During the course of this research, the experimental equipment was used in five different settings. All fourth grade Ss were run in a small room adjacent to their classroom. Some of the sixth grade Ss learned the material in the small room adjacent to the sixth grade classroom but when committee work needed more space the experimental setting was moved to the TV demonstration room. About 70 per cent of the high school students learned the stimulus material in the health room of the school building. When the spring semester opened and the room was needed to teach educational methods to student teachers, the experimental equipment was moved to the education building. The last 30 per cent of the high school students participated in a testing booth equipped with a one-way viewing screen. The extent of any biasing effect of the numerous experimental settings is purely conjectural but

the E subjectively feels it was negligible. All settings were relatively free from distractions.

Prior to the running of the experiment, data sheets had been prepared for each S indicating the order in which the S would learn the three levels of meaningful material. The sequence of events during the experimental session was as follows:

1. S was excused to go to the experimental room.

2. E chose eight pairs from the appropriate stimulus pool after shuffling the cards.

3. S is seated and the following instructions are read by E:

> You are going to be in an experiment concerned with how students learn. I am going to show you eight cards like this (E shows sample card) with a syllable on one side (E points to the stimulus element) and a letter or double letter on the other (E points to the response element). After shuffling the cards, I will show you the cards one at a time with only the syllable showing and your job will be to tell me what letter or double letter belongs with the syllable (E reverses sample card). Had this been one of the cards, you would say . . . .? (If S gives correct response, E says, "Good.") Sometimes the cards may change but you do the best you can to learn the cards I show you.

4. Since the experimental conditions for each S had been predetermined the appropriate material was presented to the S by exposing a pair at the viewing window every 2.9 seconds. Exposure was accomplished by putting the set of eight pairs in the box behind the viewing window and removing the visible card at the prescribed rate. One learning trial was concluded when each pair of the set had been exposed.

5. Following the presentation of the eight pairs the cards were shuffled and the reverse side with the stimulus syllable alone typed on the card was presented to the S at the viewing window. The S was allowed 5.8 seconds to respond with the correct letter or double letter response. Timing was accomplished by removing a card every second click of the controlled reader. During the test trial the E piled the correct and the incorrect responses separately. For Ss receiving the single trial learning condition, E took from the pool of stimulus pairs the same number of cards that the S missed and shuffled these with correct cards for the subsequent learning trial. Repetition Ss had the original set of eight pairs presented again after shuffling. This learning trial-test trial sequence was continued until one errorless trial or until E felt the S was not going to master the material. The E recorded the number of pairs correct on each test trial, thus providing the necessary data for the three response measures, i.e., number of trials to the criterion of one errorless test trial, average number of pairs answered correctly on each trial, and total errors made in reaching criterion. Ss were not routinely informed of the correctness or incorrectness of a response. Occasionally Ss requested to know if a particular pair had been correct or how many of the list had been correct. In the interest of rapport the E answered these queries.

6. For grades six through twelve, E also recorded the list of syllables learned by both the single trial and the

repetition groups. The E conducted a brief interview after the S had mastered the third list. The E initiated the interview with the statement, "Tell me how you went about learning the list you just learned." The set of cards containing the syllable just mastered by the S was displayed before the S. Comments, particularly relating to mnemonics, were recorded by E.

CHAPTER IV

LIMITATIONS

Some limitations of this research are a result of methodological factors. E was faced with the problem of selecting learning material that would not be too easy for seniors in high school yet not too hard for fourth graders. Preliminary testing of material led to the conclusions that lists longer than eight pairs and lists composed of syllable-syllable pairs would be extremely difficult for low achievement elementary school Ss to learn. The adoption of syllable-letter type pairs which were easier for fourth graders to learn eliminated the problem of having Ss attempt to pronounce the syllables but had the disadvantage of a restricted item pool of fifty items which was exhausted numerous times in the single trial condition. The experimental design used was balanced, and missing data would have so complicated calculations that it was decided to substitute other Ss from the student roll for Ss who failed to learn the material in a reasonable amount of time. Scheduling difficulties made it unfeasible to adhere to a rigid criterion for eliminating Ss due to E's own teaching commitments, lunch hour, etc., but in the main students were eliminated if they had not achieved fifty per cent mastery of the list in

forty-five minutes. Ss thus eliminated were replaced by selecting a student of the same sex, where possible, whose achievement score most nearly approximated the eliminated S. The ever present problem of sequence effect in repeated measures designs may have obscured some of the main effects. The number of Ss available by grades negated the use of complete factorial design; however, Gaito's (1958) suggestion for randomizing sequence in which S learned different material was followed. The restricted number of available Ss also prohibited the incorporation of a second control group (Underwood, Rehula and Keppel, 1962; Postman, 1962) who would have learned, by the repetition procedure, the list mastered by single trial learning Ss.

The order in which Ss were run was mostly sequential, but a great deal of liberty was taken by E in selecting Ss of different achievement classification and different meaningful material to be learned according to the amount of time available. The result was that while the interval between two sittings for one S may be five days, another S might participate three successive days.

The question has been raised as to whether the method used in this research is really critical to the issue of continuity versus noncontinuity learning. Authorities differ on this unsettled point and a more complete discussion of this problem has been given in the review chapter.

Finally, the method of this research is quite removed from the applicability of human learning in classroom settings.

CHAPTER V

RESULTS

Most experiments investigating single trial learning have some Ss who fail to reach criterion. It was decided to maintain the balance of the experimental design by replacing Ss failing to reach criterion with substitutes matching the original Ss as much as possible. Eight of the Ss failing to reach criterion learned by single trial while only four learned by repetition; however, this difference was not significant (chi square = 1.33, d.f. = $p > .10$). Of the twelve Ss who failed to reach criterion, ten were males and only two were females; this difference was significant (chi square = 5.33, d.f. = 1, $p < .025$). One of the female Ss who did not reach criterion was in fourth grade; the other was in twelfth grade. Five of the eight males failing to reach criterion were in the fourth grade. Sex was not considered a factor in the main analysis of this research; however, the t value of the difference between males and females in number of trials required to reach criterion was not significant ($t = .44$, d.f. = 58, $p > .10$). The number of Ss failing to reach criterion by grade ranged from seven in fourth grade to only one in grades six, eight, and ten. This difference is significant (chi square = 11.17, d.f. = 4, $p < .025$).

The analysis of variance for total trials to criterion of one perfect recitation, total errors in learning the list to criterion and the average errors per trial are presented on Tables 1, 2, and 3. In general, the three response measures yielded the same results. The main findings are:

1. No significant difference between the single trial and the repetition learning groups in learning paired associates. The null hypothesis is accepted (see Fig. 1).

2. A significant main effect associated with grade level was found, which ranged from minimal significance with the response measure of average errors to high significance for the response measure of trials to criterion. Tukey's D statistic (D = 6.4) for multiple comparisons of means (Snedecor, 1956) showed that fourth graders required significantly more trials to criterion than both twelfth and eighth graders. The grade level curve (Fig. 4) conformed to the predicted shape with the exception of the unexpected inferior performance of tenth graders. In general, the second specific hypothesis was supported.

3. The F value for achievement failed to reach significance on all three response measures. The means, however, are in the expected ordinal relationship (Fig. 3).

4. Meaningfulness was a highly significant factor in learning paired associates with all three response measures. Tukey's D indicated (D = 3.4) that it took significantly more trials to learn low meaningful material than medium or high

Table 1

Analysis of Variance for Number of Trials to Criterion

Source	df	MS	F
Total	179	72.53	
Between Groups	29	113.13	-
A (single trial-repetition)	1	31.25	-
B (age)	4	374.88	4.28 **
Linear	1	716.84	8.18 **
Quadratic	1	216.07	-
Cubic	1	139.38	-
Quartic	1	27.24	-
C (achievement)	2	119.84	-
Linear	1	232.41	-
Quadratic	1	7.22	-
A B	4	66.31	-
A C	2	109.02	-
B C	8	84.98	-
A B C	8	93.40	-
Error (a)	30	87.57	
Within Subjects	120	58.97	
D (meaningfulness)	2	949.32	18.24 **
Linear	1	1817.41	34.92 **
Quadratic	1	81.22	-
A D	2	58.02	-
B D	8	34.72	-
C D	4	50.92	-
A B D	8	25.62	-
A C D	4	91.08	-
B C D	16	21.82	-
A B C D	16	33.70	-
Error (b)	60	52.04	

** $p \leq .01$

Table 2

Analysis of Variance for Total Number of Errors

Source	df	MS	F
Total	179	1,608.75	
Between Groups	29	2,384.84	-
A (single trial-repetition)	1	1,264.05	-
B (age)	4	6,717.35	3.83 *
C (achievement	2	3231.10	-
A B	4	1,310.59	-
A C	2	2,114.82	-
B C	8	1,434.53	-
A B C	8	1,702.06	-
Error (a)	30	1,751.90	
Within Subjects	120	1,385.40	
D (meaningfulness)	2	20088.09	16.04 **
A D	2	1,201.86	-
B D	8	729.16	-
C D	4	993.36	-
A B D	8	991.89	-
A C D	4	2,017.24	-
B C D	16	556.32	-
A B C D	16	864.49	-
Error (b)	60	1,252.08	

* $p < .05$
** $p < .01$

Table 3

Analysis of Variance for Average Errors Made per Trial

Source	df	MS	F
Total	179	.737	
Between Groups	29	1.034	-
A (single trial-repetition)	1	.477	-
B (age)	4	2.312	2.83 **
C (achievement)	2	1.879	-
A B	4	.630	-
A C	2	.476	-
B C	8	.928	-
A B C	8	.701	-
Error (a)	30	.817	
Within Subjects	120	.645	
D (meaningfulness)	2	5.781	12.05 ***
A D	2	.512	-
B D	8	.756	-
C D	4	.551	-
A B D	8	.691	-
A C D	4	1.160	2.42 *
B C D	16	.524	-
A B C D	16	.573	-
Error (b)	60	.480	

* $p < .07$
** $p < .05$
*** $p < .01$

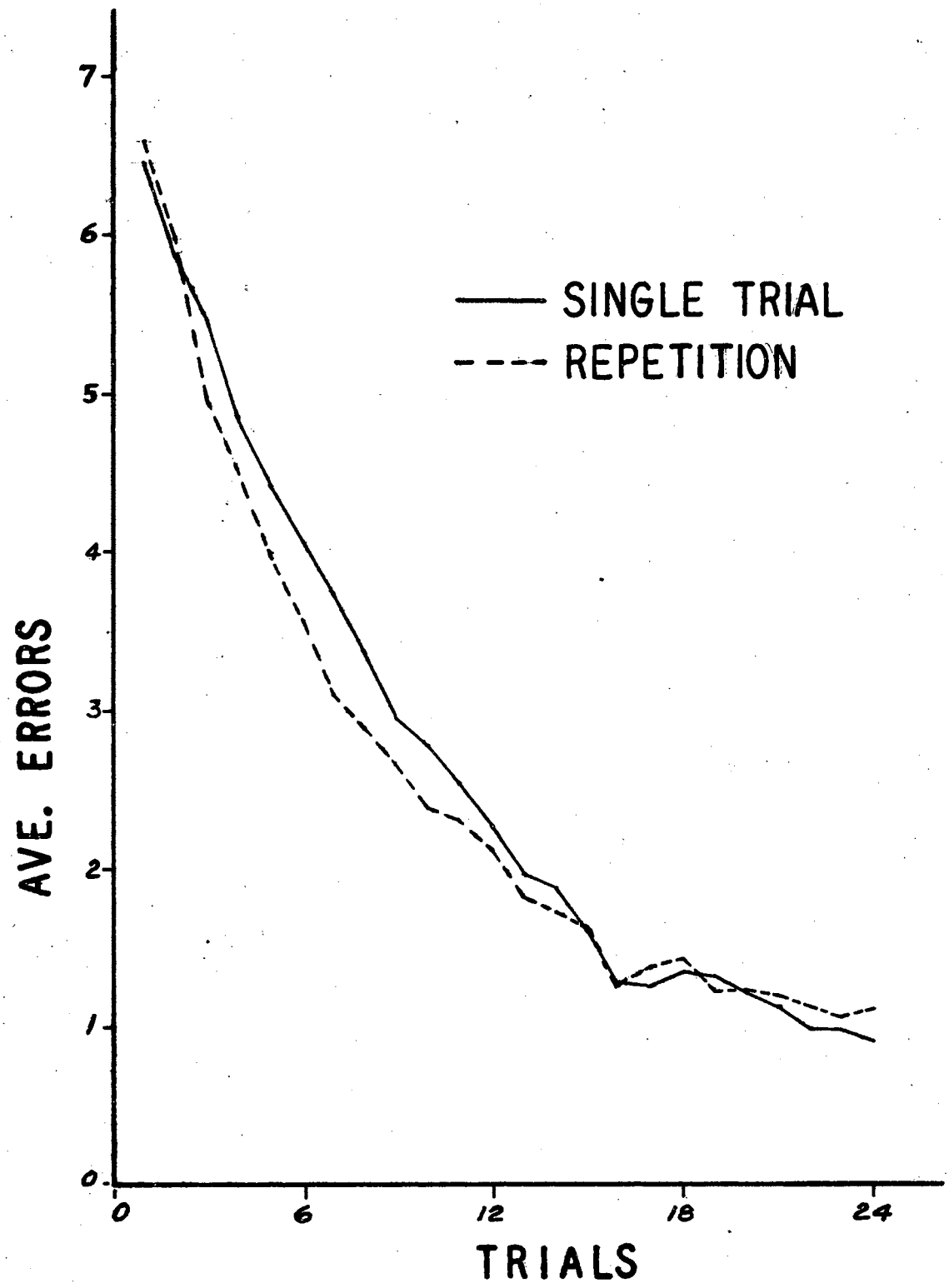

Fig. 1 Mean Errors per Trial for Single Trial and Repetition Learning

meaningful material. The difference between learning medium and learning high meaningful material was not significant (Fig. 2). The findings clearly confirmed the sixth hypothesis.

5. Not one of the two-factor interactions was significant. It was hypothesized that the factors of age, achievement, and meaningfulness would significantly interact with the main-effect of single trial vs. repetition learning. However, the three factor interaction of single trial vs. repetition learning x achievement x meaningfulness (ACD) was always larger than the other interactions and, though it failed to reach significance at the conventional .05 level of confidence, it was significant at the .07 level for the response measure of average errors ($F = 2.42$, d.f. = 4 and 60, $p < .07$). The nature of this interaction is plotted in Fig. 5.

6. The F ratios for trends are presented in Table 1. Grade level showed a highly significant linear trend. Achievement failed to yield significant linearity while meaningfulness was significantly linear. The curves associated with grade and meaningfulness tend toward negative acceleration (Figs. 2 and 4).

In addition to the analysis of variance reported above, mean number of errors made by both the single trial and the repetition group were plotted for the first twenty-four trials (Fig. 1). This figure indicates the general form of both groups' learning curves. Two limitations restrict interpretations of this data: (1) the plotted averages

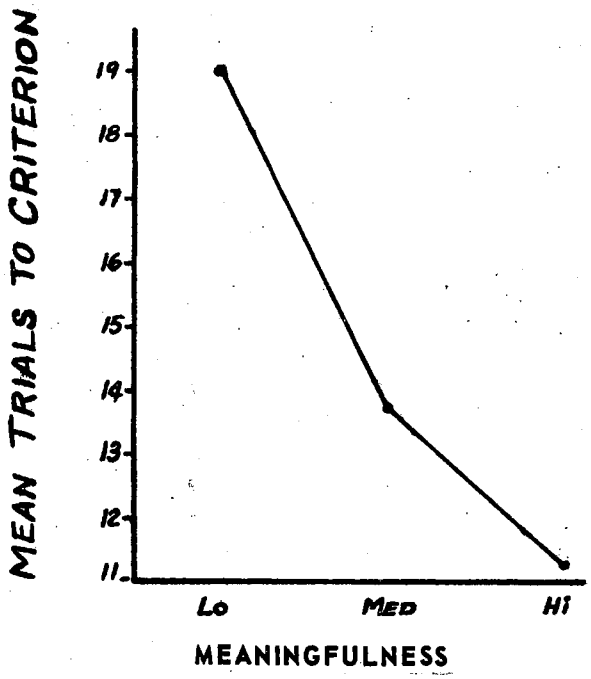

Fig. 2 Mean Trials to Criterion for 3 Levels of Meaning

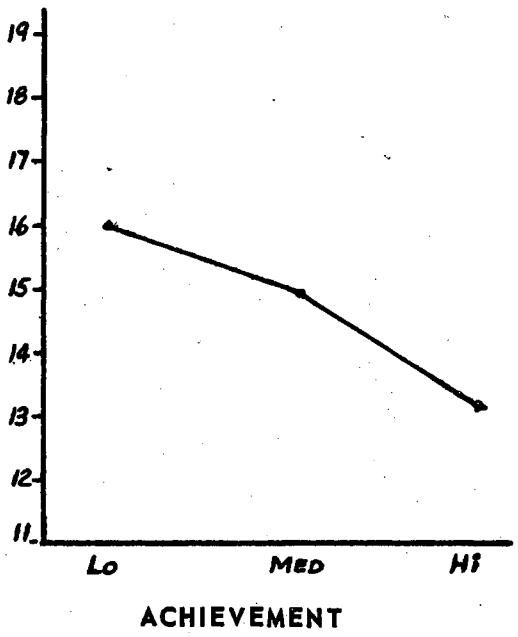

Fig. 3 Mean Trials to Criterion for 3 Levels of Achievement

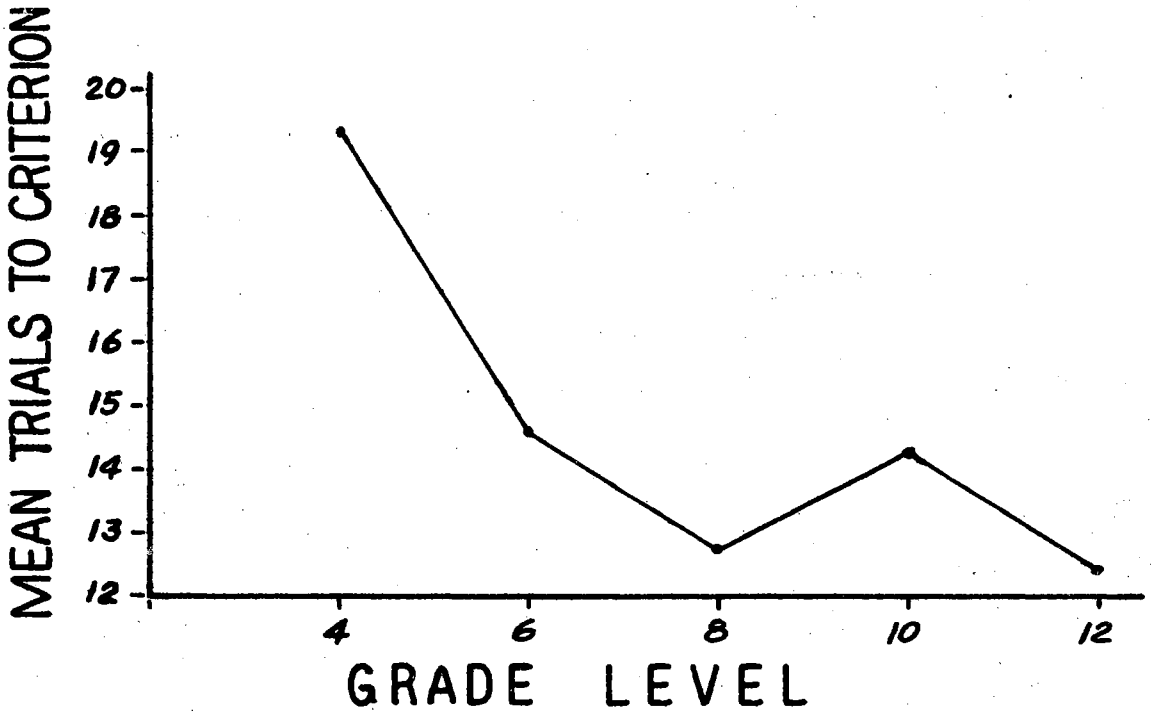

Fig. 4 Mean Trials to Criterion for Grade Levels 4-12

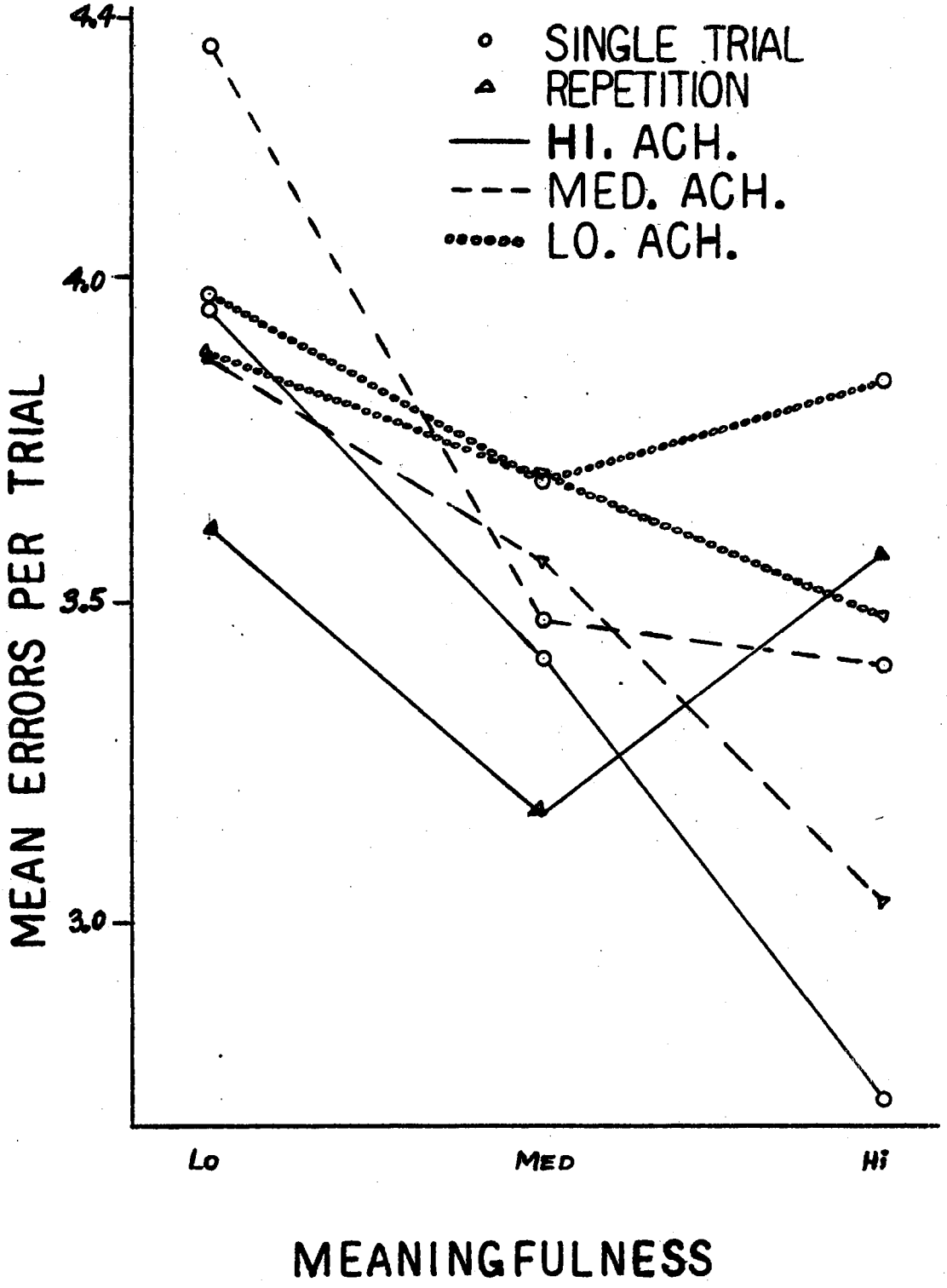

Fig. 5 The Interaction (A C D) of Single Trial – Repetition Learning with Achievement and Meaningfulness

the Ss who had mastered the material, and (2) the number of Ss was not constant. The number of Ss ranged from sixty Ss on the first trial to eight Ss on the twenty-fourth trial. The single trial group was inferior to the repetition group from trial three to trial fifteen, though the differences were slight and failed to reach significance on the two trials where the differences are maximum--trials seven (t = 1.70, $d.f.$ = 56, $p > .05$) and eight (t = .98, $d.f.$ = 55, $p > .05$).

An ad hoc analysis of the trials to criterion data was made to get a general indication of the influence of order which was not a controlled factor in the experiment. The six possible orders of learning the three levels of meaningfulness material had been randomly assigned to Ss. Analysis of variance (Table 4) showed order as a nonsignificant factor.

The final list of eight pairs learned by both single trial and repetition Ss were recorded. Analysis by chi square disclosed that some pairs had a greater tendency to be learned by single trial learning Ss than other pairs (Appendix B). Assuming random sampling of pairs, each pair had the expectancy of being learned by four Ss. Chi square values are based on deviations from this expectancy. There is a tendency for the magnitude of the chi square values to increase when going from the high meaningfulness level to the low for both the single trial learning and the repetition groups. Whether the response element is a single or a double letter did not seem to make the pairs significantly easier

Table 4

Analysis of Variance of Order Effect for Trials to Criterion

Source	df	MS	F
Total	59	300.35	
A (single trial-repetition)	1	93.75	-
B (order of presentation)	5	219.87	-
A B	5	504.33	-
Residual	48	291.79	

* $p > .10$

(chi square = 1.17, d.f. = 1, $p > .10$). When the number of Ss learning a particular pair was summed over levels of meaningfulness, the pairs with a common response element but different stimulus syllables yielded a significant tendency for some pairs to be either preferred or rejected for the single trial learning Ss (chi square = 133.15, d.f. = 49, $p < .005$). A similar analysis for pairs learned by repetition Ss (chi square = 31.9, d.f. = 49, $p > .10$) constitutes a control group since these Ss had no opportunity to select items. This finding suggests a contributory role of the response element in item selection.

CHAPTER VI

DISCUSSION

Single Trial Learning

The first specific hypothesis of this research was that of no difference (null hypothesis) between the single trial and the repetition learning groups. The slight superiority of the repetition groups in this study lies well within the chance expectancy range of statistical probability. The interpretation of this predicted nonsignificance is complicated by the failure of the following two factor interactions to attain significance: single trial vs. repetition learning x age, single trial vs. repetition learning x achievement, and single trial vs. repetition learning x meaningfulness.

The age variable conformed to expectation by yielding a significant F ratio. Its plotted shape is one of negative acceleration associated with increased grade level. However, tenth graders performed less well than eighth graders and, in general, one confidence interval would encompass sixth, eighth, tenth, and twelfth graders, leaving only fourth graders significantly less apt.

The interaction of grade level with single trial learning, though not significant, conforms at least generally to the general hypothesis of this research since single trial

learning Ss are almost equal in performance to repetition Ss at fourth grade, repetition Ss perform better than the single trial Ss in sixth and eighth grades, and single trial Ss perform better in tenth and twelfth grades.

Achievement as a main effect fails to reach significance (Factor C). This finding cannot be construed to mean that level of achievement does not influence paired associate learning since achievement in this research was relative within grade level, different tests were used at elementary and secondary levels, and attempts to increase homogeneity within achievement groups eliminated deviantly bright and dull students. The nonsignificant interaction of achievement with the single trial-repetition factor is hard to interpret. As predicted, the low achievement Ss learn slightly more efficaciously by the repetition method and the high achievement Ss learn slightly better in the single trial condition, yet the greatest difference occurs with repetition learning medium achievers out-performing the single trial medium achievers. This is clearly incompatible with the fifth hypothesis of this research.

Meaningfulness is the most significant factor influencing paired associate learning. It is also significantly linear and negatively accelerated, which suggests the associative value scale is not an equal interval one. Confidence intervals for the levels of meaningfulness do not overlap, indicating great probability of a significant monotonic relationship. A methodological limitation to be kept in mind

is that associative value norms were based on college Ss and may be inappropriate for younger Ss.

Although the interaction of meaningfulness and single trial-repetition factor is not significant, the arrangement of means nicely conforms to expectations; i. e., with low meaningfulness pairs, single trial Ss are inferior to repetition Ss but with high meaningfulness material repetition Ss are inferior.

The interaction of single trial-repetition learning, achievement, and meaningfulness (ACD) presents some interesting though somewhat ambiguous results (Fig. 5). Only the measure of average errors per trial yielded an F ratio large enough to be creditable ($p > .07$). The curves for achievement levels learning under two experimental conditions are quite diverse in shape. For high achievers, single trial learning and repetition learning cross once between medium and high meaningfulness, for medium achievers they cross twice, and for low achievers they never cross. High achievers conform nicely to predicted relation but medium and low achievers do not.

In short, the hypothesis that the single trial vs. repetition learning factor would significantly interact with the independent variables of age, achievement, and meaningfulness has not received much support from this research but is still tenable. Of the three independent variables studied, meaningfulness probably influences single trial learning most, either directly or indirectly.

Two theoretical interpretations of the role of meaningfulness in single trial learning are plausible. The first suggests that low meaningfulness necessitates response learning and interferes with the association or hook-up stage of paired associate learning. This approach would extend the Kintsch model (1963) by asserting that not only do both stages occur in one trial, but also that variations in meaningfulness will have predictable outcomes on response measures of single trial learning. A second theoretical alternative stresses the permanence of the memory trace. Meaningfulness simply reflects the amount of formed and stored associations. Initial response learning may occur on one trial but single trial learning, as investigated by Rock (1957), is not a learning phenomenon; it is a recall phenomenon. In either case, future research must control the difficulty of not only the stimulus and response elements of pairs, but also the combination of stimulus and response.

Two interpretive options are possible for the finding of no significant difference between the single trial and the repetition group: (1) accepting the results as support of Rock's single trial learning phenomenon, and (2) rejecting the single trial learning interpretation on methodological grounds.

Using the former option, the absence of two factor interactions may be interpreted as eliminating these variables as important antecedent factors, thus suggesting that single trial learning is generalized across levels of age, achievement and meaningfulness.

The primary basis of the latter interpretation is hesitancy to accept experimental phenomena on the basis of the null hypothesis (Underwood and Keppel, 1962) since lack of statistical differences may be a function of innumerable factors associated with method (small number of Ss, unreliable experimental conditions, heterogeneity of Ss, etc.). The presence of significant item selection also encourages the more cautious interpretation.

Had single trial learning significantly interacted with the independent variables investigated, it could have been said that single trial learning depends upon those variables. Since it did not, and taking the other factors discussed above into consideration, the most defensible conclusion stemming from this investigation of single trial learning, as promulgated by Rock (1957), is that the phenomenon still has not been verified unequivocally. However, since the principle basis for this conclusion is reluctance to accept confirmation of a null thypothesis as proof of the theory, thus making proof of the theory impossible, it must be concluded that these results, if they do not prove Rock's thesis, are supportive of it. It is possible to suggest that by the time any child is in school all verbal forms have acquired some associative value with all other verbal forms and that the original associative learning was of an incremental type. This speculation suggests that all studies done so far in the area are not studies of original learning but are studies of the strengthening of more or less well formed associations.

The broader issue of single trial vs. incremental learning merits some discussion. The single trial learning topic was broached several times in the First Conference on Verbal Learning and Verbal Behavior sponsored by the United States Office of Naval Research and New York University (Cofer, 1961). Single trial learning was deemed of sufficient import to incorporate a discussion of the status of the issue by Postman at the second conference of the same name (Cofer and Musgrave, 1963). In his paper, Postman attacks the contemporary approaches to human single trial learning of Rock (1957) and Estes (1960) for failing systematically to relate single trial learning with the other important learning variables of acquisition, retention, and forgetting. Postman dismisses Rock's work as an artifact of item selection and asserts that the accumulated evidence in support of the incremental nature of learning cannot be placed in jeopardy by the one experimental paradigm. He concludes the review by saying,

> Theories die hard, and crucial experiments are rarely successful in psychology. To the extent that the current controversy has led to an increasingly careful examination of the details of the learning process, it has served a useful purpose (Cofer and Musgrave, 1963; p. 320).

George Miller delivered the rejoinder to Postman's paper (Cofer and Musgrave, 1963). He presents the following four arguments for the continued relevancy of single trial learning:

1. He describes "junk box" theories of single trial

learning. The analogy likens a response element to the miscellaneous nuts, bolts, and washers that are stored in a container. The time to locate a particular item after it has been placed in the box depends on how long ago it was put in and how many items were like it. Thus, the analogy of the item either being in the box or not being in the box, to single trial learning loses much of the discrete white and black distinction suggested by Postman.

2. Nancy Waugh, in an unpublished experiment, reversed Rock's conditions by eliminating the pairs learned after each trial. She found that Ss could distinguish between the old and the new pairs. Something has been learned during the unsuccessful presentation as measured by a recognition, while, for a recall measure, every trial appears to be a first trial. This experiment is offered in support of a more pluralistic approach to single trial learning.

3. Newell, Shaw, and Simon use a computer to simulate human cognitive processes. The computer either having or not having the symbol presented for storage, likens the computer operation to single trial learning, yet plotted latency of locating symbols yields an incremental function associated with order of storage and distinguishable characteristics of the symbol.

4. Feigenbaum and Simon's EPAM (Elementary Perceiver and Memorizer) Theory replicates serial position curves with computer simulation, again with the either-or assumptions about the S-R connections.

Miller would like to convert the single trial issue into a question "When the processing (whatever it is) is interrupted, can it later be resumed at the same point, or must it be started over afresh" (Cofer and Musgrave, 1963; p. 327)? If it can resume where it was interrupted, then the learning will appear incremental. If, on the other hand, acquisition must begin anew, learning by single trial will best describe the acquisition. To Postman's comment that theories die hard, Miller reacts with,

> Sometimes I suspect that they never die. They don't even fade away. They just become uninhabited. For the time being, however, both of the theories we have been comparing here seem well populated by vigorous, opinionated exponents. The future looks interesting indeed" (Cofer and Musgrave, 1963; p. 328).

Some concluding suggestions and comments are in order regarding the nature and future of single trial learning. Two definitional problems tend to render the issue obscure. One is the lack of definition or agreement upon what is the unit or element of learning. In general, as the definition becomes more microscopic, the element or unit becomes more compatible with a single trial interpretation. The other definitional problem has been the relation between the construct of memory trace on the one hand and threshold on the other. Clarification of the relation of single trial learning to both these constructs would do a great deal toward clearing some of the ambiguity associated with single trial learning. Some limitations and restrictions on the generality of single trial learning may be necessary. Mandler, another

conference participant, cautions that single trial learning may be inadequate as a general principle; however, under some conditions it always occurs (Cofer and Musgrave, 1963). Finally, it seems to this investigator that the most propitious instrumentation for exhaustive exploration is the digital computer. The exploration via simulation seems a ready-made methodological approach to confirmation or disconfirmation of single trial learning, particularly if Miller's question provides the theoretical rationale.

Rehearsal and Mnemonics

During the course of this experiment the E had a unique opportunity to observe the Ss while they were learning the pairs. The S was visible to E for an instant every time a stimulus card was changed during the test trial and when the experimental setting was moved to the Education Building, the equipment was so arranged that the viewing window acted as a mirror, giving the E a side view of the S at his task. Ss were generally unaware of this scrutiny. One S who started to copy the stimulus material on his hand had to be informed that he was under surveillance. The E observed considerable rehearsal of Ss even with the eliminated inter-exposure interval. One little sixth grade girl would select a pair to be mastered and during the test trial would mutter the response over and over until the desired card was presented. After the anticipated card had been presented, no overt lip movement could be detected. During the short interview

following the S's learning the last list some Ss stated that they spent part of the time rehearsing. One sixth grader remarked, "I kept saying it over and over in my head, so that when you showed it I was saying it in my head."

Although this rehearsal by the Ss may represent a source of bias in investigation of single trial learning, Miller's rejoinder to Postman suggests a quite different role:

> Postman refers to this rehearsal strategy as an artifact, but if Feigenbaum and Simon are on the right track it may well be the most important fact of all (Cofer and Musgrave, 1963; p. 326).

The short interview also disclosed the use of mnemonic devices similar to those reported in previous studies (Clark, Lansford and Dallenbach, 1959). These devices are classified into seven types listed below with a few examples of each type.

1. Abbreviations: this seldom reported device uses the letters in the pairs to remind them of initials of friends, relatives, etc., or other abbreviations (ZEH-Q; H. Q. is the abbreviation for headquarters).

2. Similar sounds: the stimulus element contains units phonetically similar to the response element (ZYV-F, ZOS-CC; f and v; c and s sound alike).

3. Pronunciation: S pronounces all the letters in the pair (XOL-T = zŏlt; WOR-BB = wôrb).

4. Word connection: S makes one word for the stimulus element and another for the response element that share some meaningfulness relationship (FAL-S = fall slow; VAS-F = vase and flowers).

5. Alphabetical sequence: S selects a letter from the stimulus that is located alphabetically adjacent to the response letter (VYQ-Z = y is before z; CIJ-B = c is after b).

6. Structural similarity: S associates similarity of shape or alters some characteristic of the stimulus element to resemble the response element (XOW-E = w looks like e on its side; CUS-ZZ = z is s turned backward).

7. Word construction: this most commonly reported device derives a word containing all or part of the stimulus element and the response element (DIS-T = district; QIV-R = quiver; FUS-H = fish or flush).

CHAPTER VII

SUMMARY AND CONCLUSIONS

The Issue

One theoretical issue that has permeated learning theory during the last several decades has been whether learning occurs in a single trial or requires repetition. Irwin Rock (1957; 1959), in a series of experiments involving the learning of paired associates, found that when unlearned pairs were removed from a list after every trial and replaced by new ones (single trial learning group) the number of trials to criterion was not more than when the traditional procedure (repetition group)) was used. Rock has used the results of these experiments to conclude that learning occurs on one trial rather than by a process of gradual strengthening.

In the controversy that has ensued, there has been some support of Rock's results and considerable criticism of his methodology. The general hypothesis of this study was that the single trial learning effect obtained by Rock would be altered by variations in age and achievement level of the Ss and by the meaningfulness of the stimulus material.

Method

Students in the laboratory school at Kansas State College of Pittsburg were selected from grades four, six, eight, ten, and twelve according to three levels of achievement and randomly assigned to either the single trial learning group or the repetition group. The pairs learned by the Ss contained a nonsense syllable as the stimulus element and a letter or double letter as the response element. Nonsense syllables were selected from three levels of an associative value scale and each S learned three lists of eight pairs to the criterion of one errorless trial. Single trial learning Ss had pairs of a particular associative level missed on a given trial removed from the list and new pairs from the pool of pairs at the same associative level substituted. Repetition learning Ss continued learning the same eight pairs until mastered. Order in which the three different meaningful levels were learned was randomly assigned to Ss. An analysis of variance was performed on three measures of learning: total trials to criterion of one errorless trial, total errors to criterion, and mean errors per trial.

Hypotheses and Findings

Support of the general hypothesis necessitated that differences between single trial learning and repetition learning vary with the independent variables of age, achievement, and meaningfulness. Thus, younger Ss should learn

more efficaciously via the repetition method while older Ss should learn better via the single trial method. Low achievers should learn more readily via repetition method while high achievers should learn better via single trial method. Finally, Ss should learn pairs more readily by the repetition method when the pairs are low in meaningfulness and more readily by the single trial method when the pairs are high in meaningfulness. In general, these predictions were not confirmed. The main-effect of single trial vs. repetition learning was not significant; however, the interaction of independent variables with single trial vs. repetition learning failed to reach significance. The limited and inconclusive support of the general hypothesis lies in the marked three factor interaction of the single trial-repetition learning factor, the achievement factor and the meaningfulness factor, when performance was measured by mean errors per trial. The interpretation of this three factor interaction is difficult because single trial performance, though influenced by achievement and meaningfulness, does not conform to predictions of the general hypothesis.

In summary, the finding of no significant difference between the single trial learning group and the repetition group, as was found by Rock (1957), was not interpreted as proof for single trial learning by this writer because there was significant item selection found for single trial learning Ss, despite the fact that two factor interactions failed to reach the predicted significance. However, the

failure to find significant differences is compatible with the results of Rock.

Item selection was detected by counting the number of times each pair appeared on the final list of eight pairs learned by the single trial and the repetition Ss respectively, and comparing the observed with the expected frequency via chi square. It was found that some pairs appeared either more often or less often than expected on the mastered list of single trial Ss but not lists of repetition subjects. The potential biasing of item selection suggests that future research take into consideration meaningfulness of the stimulus material.

Grade level and meaningfulness were the significant factors across the three response measures and also yielded significant linear trends for trials to criterion. In other words, age and meaningfulness were significant factors in paired associate learning but not in single trial learning since they did not significantly interact with that factor.

Suggestions for Future Research

Future investigation of single trial learning should incorporate adequate control of the stimulus material's meaningfulness. To insure homogeneity of the stimulus material it is suggested that pairs be scaled on a continuum of difficulty and only pairs of similar scale value be put in any one list. Scaling could be done by judges' ratings or some learning criterion such as mean trials required to master a

particular pair. The sample of Ss used to scale the pairs would, of course, be a different sample than the subjects used in the single trial learning experiment. Another control recommended is the utilization of a second repetition group (Underwood, Rehula, and Keppel, 1962; Postman, 1962) that learns the list of pairs mastered by the single trial learning group. Thus, differences between the repetition group, whose pairs to be learned have been randomly selected from the stimulus pool, and the second repetition group, whose pairs to be learned have previously been learned by single trial learning subjects, would represent an estimate of the effects of item selection associated with the single trial learning condition.

It seems to this writer, that age investigated via cross-sectional designs hold little promise for resolving the issue of single trial learning. Attempts to subdivide subjects of different age levels into comparable ability groups is complicated by the shortage of tests that span a sizable portion of the age dimension. Although single trial learning studied longitudinally would eliminate the difficulty of sampling equivalent age groups, future research might adopt a more fruitful strategy.

It is recommended that the general strategy for future investigation of single trial learning begin with an attempt at clear differentiation of single trial and incremental learning. Definition of single trial and incremental learning should include specific statements concerning the conditions

under which each type of learning should occur. Conditions which lead to predictions of performance differences between single trial and incremental learning should be explored with experiments focusing on the predicted differences. If the process of defining single trial and incremental learning suggests a two-stage model of human verbal learning, then predictions associated with a particular model should be subjected to experimental verification. Four two-stage models for paired associate learning are plausible. (1) The initial or response learning stage occurs incrementally and the subsequent or associative stage also occurs incrementally. (2) Though the response learning stage occurs incrementally, subsequent associations are made on one trial. (3) Where the unit of learning is considered to be small, it is possible to suggest that responses are learned or not learned on any given trial while the associative stage may occur by a process of gradual strengthening. (4) Finally, both the response learning stage and the association or hook-up stage may be viewed as occurring in a single trial.

The establishment of single trial learning as a verified phenomenon would strengthen the computer simulation approach to cognitive activity (Newell, Shaw and Simon, 1958; Hovland, 1960; Feigenbaum and Simon, 1962). One of the most heuristic approaches to single trial learning has been the employment of mathematical models (Estes, 1950; 1959; Kintsch, 1963; Bower, 1961). However, computer simulation will not, and need not, wait for the resolution of the single trial learning issue.

It seems likely that these two contemporary developments in learning theory of computer simulation and mathematical models cited above will complement each other in pursuing a resolution of the single trial learning controversy.

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APPENDIX A

APPENDIX A

RECRUITMENT LETTER SENT TO HIGH SCHOOL STUDENTS

Room 106
Hughes Hall
Kansas State College of Pittsburg
December 6, 1963

Dear

I am engaged in a research project that will aid us in understanding the process of human learning. I want to help answer the question, "How do we Learn?" Your name has been selected from the College High enrollment as one who would help me. If your volunteer, your job will consist of learning three sets of verbal material at different times. The total experimental time should be about one hour and the experimental sessions would be scheduled during your library period if you are an 8th or 10th grader and during your free period if you are a senior. The results of your performance will in no way influence your class grades and will be held in confidence by me.

Please check the appropriate space below and return the bottom part of this letter to the principal's office.

Yours truly,

John J. Rearden
Asst. Professor of Psychology

_____ I will participate

_____ I will not participate

Sign Here _____

APPENDIX B

APPENDIX B

STIMULUS MATERIAL BY MEANINGFULNESS LEVELS (HIGH)

Response Element	Stimulus Syllable	Single Trial[a]	Repetition[a]
A	JOK	7	3
B	JYN	4	4
C	GUL	2	4
D	BAW	5	2
E	JYM	6	4
F	DAS	4	5
G	WEK	2	6
H	FUS	3	5
J	MEL	3	4
K	BAL	4	5
L	KAN	5	3
M	RUS	5	5
N	JUS	2	5
O	WIC	7	8 *
P	RAC	1	3
Q	LIC	3	1
R	WUN	3	5
S	FAL	7	3
T	DIS	4	4
U	PUD	9 *	3
V	LOS	3	2
W	MES	2	4
X	NIL	2	4
Y	CIG	5	1
Z	FYR	5	6
AA	GOR	10 **	2
BB	WOR	3	5
CC	WIF	1	2
DD	VOT	2	5
EE	GIL	2	5
FF	COK	2	3
GG	TUF	2	4
HH	JEF	3	5
JJ	BIL	9 *	4
KK	RAD	2	2
LL	TOX	2	4
MM	NOZ	2	7
NN	SEZ	3	3

(continued)

Response Element	Stimulus Syllable	Single Trial[a]	Repetition[a]
00	DAL	10 **	5
PP	HAK	3	4
QQ	JEN	4	3
RR	SIC	2	5
SS	WAT	2	3
TT	FIL	2	2
UU	KUR	5	4
VV	TOS	6	4
WW	CEL	2	2
XX	MOL	2	2
YY	LUF	1	4
ZZ	CUS	7	4
Cumulative Chi Square Value		69 **	26

* $p < .05$[b]
** $p < .005$

a Number of times each pair appeared on final lists mastered by 6th, 8th, 10th, and 12th grade Ss.

b Chi Square values are based upon deviations from the expectancy of approximately four Ss having each pair on their mastered list.

STIMULUS MATERIAL BY MEANINGFULNESS LEVELS
(MEDIUM)

Response Element	Stimulus Syllable	Single Trial[a]	Repetition[a]
A	JED	15 **	3
B	KUX	2	6
C	LUH	5	5
D	NYG	2	3
E	PUW	7	2
F	QOK	1	7
G	WEZ	2	5
H	BAZ	2	5
J	CUY	7	4
K	LIH	3	3
L	KAG	5	3
M	HEZ	2	1
N	CAJ	3	5
O	BUQ	10 **	4
P	TAV	5	5
Q	SIW	4	2
R	QIV	7	5
S	GOZ	5	5
T	MIH	3	4
U	DAK	7	2
V	MUH	5	3
W	MUY	2	2
X	NOF	4	2
Y	TEH	3	3
Z	QEY	3	5
AA	BEY	3	2
BB	ZAY	3	4
CC	ZOK	2	5
DD	BOP	5	1
EE	HUW	4	8 *
FF	CEG	1	4
GG	CEX	1	5
HH	FEG	4	2
JJ	QUS	1	6
KK	JUC	3	5
LL	TYS	3	2
MM	ZIN	9 *	3
NN	GYF	5	2

(continued)

Response Element	Stimulus Syllable	Single Trial[a]	Repetition[a]
00	GYF	5 *	2
PP	KOH	0 *	5
QQ	MYH	3	5
RR	QAV	4	6
SS	TUD	7	3
TT	VOD	4	2
UU	ZOX	2	5
VV	DYW	1	7
WW	JEC	2	3
XX	JIZ	3	4
YY	FIH	0 *	3
ZZ	FUY	4	2
Cumulative Chi Square Value		89 **	33

* $p < .05$[b]
** $p < .005$

a Number of times each pair appeared on final lists mastered by 6th, 8th, 10th, and 12th grade Ss.

b Chi Square values are based upon deviations from the expectancy of approximately four Ss having each pair on their mastered list.

STIMULUS MATERIAL BY MEANINGFULNESS LEVELS
(LOW)

Response Element	Stimulus Syllable	Single Trial[a]	Repetition[a]
A	WOJ	9 *	4
B	CIJ	3	5
C	QUX	1	3
D	XUR	2	2
E	XOW	6	4
F	XUB	1	1
G	XOC	2	2
H	SYJ	5	3
J	GUC	1	4
K	FEQ	5	3
L	XAP	2	3
M	QOC	1	5
N	GIK	5	2
O	JYH	2	1
P	QIF	3	3
Q	ZEH	4	5
R	SYR	3	7
S	SYB	2	4
T	XOK	3	3
U	QIW	5	1
V	GOC	3	6
W	JYV	4	6
X	KEV	7	3
Y	ZIJ	1	3
Z	VYG	4	5
AA	VIF	7	7
BB	ZUH	4	2
CC	ZOS	6	5
DD	ZOB	1	7
EE	QOB	2	2
FF	ZYB	1	6
GG	YAD	6	3
HH	XOY	1	5
JJ	QOP	1	6
KK	VUP	2	3
LL	VUB	4	3
MM	PIB	8 *	3
NN	ZOQ	5	5

(continued)

Response Element	Stimulus Syllable	Single Trial[a]	Repetition[a]
OO	TEV	16 **	5
PP	QOX	3	4
QQ	MEF	2	3
RR	TYV	4	2
SS	VUD	9 *	3 *
TT	XOL	8 *	5
UU	XYF	3	2
VV	GIX	3	7
WW	KIF	1	2
XX	MYP	1	5
YY	JUF	3	5
ZZ	MYV	5	4
Cumulative Chi Square Value		99 **	36

* $p < .05$[b]
** $p < .005$

a Number of times each pair appeared on final lists mastered by 6th, 8th, 10th, and 12th grade Ss.

b Chi Square values are based upon deviations from the expectancy of approximately four Ss having each pair on their mastered list.

VITA

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