71-1482

COLE, Lawrence Edward, 1945-
IMPLICIT ASSOCIATIVE RESPONSES IN THE VERBAL
DISCRIMINATION LEARNING OF CHILDREN.

The University of Oklahoma, Ph.D., 1970
Psychology, experimental

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

# IMPLICIT ASSOCIATIVE RESPONSES IN THE VERBAL DISCRIMINATION LEARNING OF CHILDREN

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

LAWRENCE E. COLE

Norman, Oklahoma

1970

IMPLICIT ASSOCIATIVE RESPONSES IN THE VERBAL

DISCRIMINATION LEARNING OF CHILDREN

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DISSERTATION COMMITTEE

## ACKNOWLEDGEMENTS

The author is indebted to Assistant Professor N. Jack Kanak, Ph.D., Chairman, Department of Psychology, University of Oklahoma for selecting me as his research assistant. During the course of this assignment (two and one-half years), Dr. Kanak patiently attempted to teach me the research skills necessary to conduct good research projects. Therefore, it is not only the suggestions he conveyed in the present research project which made completion of the dissertation possible, but also his efforts during the past two and one-half years. Thus, I hope this final research endeavor reflects both the adequacy of his teaching and my learning abilities.

The author also wishes to extend appreciation to Assistant Professors Paul D. Jacobs, Ph.D., Larry E. Toothaker, Ph.D., and Thomas M. Miller, Ph.D., for their helpful suggestions during the various stages of the study.

A special appreciation is extended to the author's wife, Patty Sue and son, Kevin Wayne who often heard, "Daddy must get to work now." Without Patty's untiring ability to suffer poverty and her understanding the past seven years the completion of the Ph.D. would have been impossible.

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Manuscript to be submitted for publication.

# IMPLICIT ASSOCIATIVE RESPONSES IN THE VERBAL DISCRIMINATION LEARNING OF CHILDREN

## INTRODUCTION

According to the frequency theory of verbal discrimination (VD) learning (Ekstrand, Wallace, and Underwood, 1966) intrapair discriminations between wrong (W) and right (R) items are based on the differential frequency accrual to these items. In addition, to the direct sources of frequency units (i.e., representational responses, pronunciation responses, and rehearsal-of-the correct response) Ekstrand et al. proposed that implicit associative responses (IARs) transfer frequency units between high associatively related items. For example, presentation of the word "table" is assumed to elicit the implicit associative response "chair," which adds an additional frequency unit to "chair". The present study is concerned with the transfer of IARs whenever the W and R item associates are paired (intrapair condition) or re-paired with opposing item function (interpair condition) in an age spectrum which included kindergarteners, first, second, and third graders. This age range was selected in an attempt to extend the investigation of the reported inability of children between the ages of five and seven to use implicit mediators in paired-associate (PA) learning to IAR manipulations in a VD task.

In a VD list composed of associatively unrelated words, Ekstrand et al. assumed the direct sources of frequency units yielded a 1:3 frequency ratio in favor of the R item. The IARs in the intra-and interpair conditions may be assumed to reduce the differential frequency cue by the transfer of IARs which summate with the direct sources of frequency units to increase the total frequency count to the W items. As the result, both lists should be more difficult to learn than a control list of unrelated words. Empirical investigations, however, have reported equivocal results.

Eberlein and Raskin (1968) and Fulkerson and Kausler (1968) used college students as Ss and found the interpair condition to be significantly more difficult than the intrapair and control conditions. However, contrary to frequency theory, the latter two conditions did not differ from each other. To explain the latter finding both sets of authors employed the tagging model as presented by Barch, Lippman, and Whalen (1967). The tagging model assumes the involvement of a compensatory process to counteract the decreased effectiveness of the differential frequency cue in the intrapair condition. According to this model, the S tags the correct item of each pair as "right" and then collapses the associated pair and its tag together to reduce the memory storage load, and thus compensates for any reduction in the frequency cue.

Barch, Lippman, and Whalen (1967) proposed the tagging model to explain the fact that the intrapair list was significantly less difficult to learn than a control list for fourth, fifth, and sixth graders. On the other hand, Palermo and Ullrich (1968), in accordance with frequency theory, found the intrapair condition to be more difficult than the control condition for fourth graders and college undergraduates. Similar findings have been reported by Ahammer and Goulet (1969) for grades one through six. It should be noted that none of the above studies included the interpair condition.

The reported disparity of results in the intrapair condition may be due, in part, to the mode and/or type of presentation of the learning materials. Barch et al. employed an oral presentation of a 16 pair list in a study-test learning procedure and found that intrapair associates facilitated learning. Other studies utilizing a visual presentation in the anticipation method either produced no effects relative to a control condition (Eberlein and Raskin, 1968; Fulkerson and Kausler, 1968) or interference (Ahammer and Goulet, 1969; Palermo and Ullrich, 1968).

It is conceivable, however, that performance in the intrapair condition may interact with age since there appears to be a stage in human development in which the child does not use available mediators to assist learning (Flavell, Beach, and Chinsky, 1966). Mediation in this context refers to an implicit response interceding between an external stimulus and an overt response. Flavell et al. characterize this inability to use available mediators as the production deficiency hypothesis. The production deficiency hypothesis should be distinguished from the earlier mediation deficiency hypothesis (Reese, 1962) which asserts that a child uses available mediators but not to assist learning in the expected manner. A number of PA studies (e.g., Jensen and Rohwer, 1965) concluded that production deficiency characterized the mediation behavior of children between the ages of five and seven. Beyond this age range, Jensen and Rohwer (1965) and Palermo (1962) reported an increase in the use of mediators as learning aids which is also consistent with the production deficiency hypothesis. It should be noted that Ahammer and Goulet found results in first graders consistent with the production deficiency hypothesis, but performance in the intrapair condition remained inferior to the control condition through grade six which is inconsistent with the production deficiency hypothesis.

Since the processes of mediation in PA tasks and the tagging procedure are similar (i.e., both are activated by the S to assist learning) the mediational phenomena in a PA task should extend directly to an intrapair IAR manipulation in a VD task. However, frequency theory assumes that transfer of IARs reduces the differential frequency cue in the intrapair condition, thus it should be more difficult to learn than the control condition regardless of the learner's age. However, the tagging model presented by Barch *et al.* predicts that tagging processes, basically a mediational process, in the intrapair list should compensate for the reduced frequency cue, thus facilitating learning in the intrapair condition relative to the interpair condition. On the other hand, if the production deficiency hypothesis correctly characterizes the mediational processes of children between the ages of five and seven then the facilitation due to tagging in the intrapair condition will not be experienced until approximately the third grade. That is, there should be an interaction between the treatment conditions and grade levels with no differences between the IAR list conditions through the second grade, but differences should appear at a third grade level if mediational processes are operative.

## METHOD

*Subjects*. The 96 students who served in the experiment were selected from the kindergarten, first, second, and third grades (n=24). The majority of the *Ss* were selected from the University School, but due to an insufficient number of children, six second and two third graders were selected from the Moore Elementary School. It should be noted the University School is affiliated with the University of Oklahoma and enrolls an intellectually above average body of children. Therefore, *Ss* from the Moore Elementary School were selected on the basis of their above average achievement. Each

S was randomly assigned to one of the three treatment conditions upon appearance at the laboratory, within the restriction of achieving equal n's in each condition.

Word Lists. To construct an 8 pair list in which the intrapair W and R items were associates, 8 primary words and their highest associates were selected from the Palermo and Jenkins (1966) norms. An attempt was made to select word pairs which had high bidirectional associative strength although the incompleteness of bidirectional norms allowed the selection of only two pairs which met this requirement. The six remaining pairs were chosen on the basis of E's judgement of relatively equal bidirectional strength. The additional restrictions imposed were that each word selected could not be over two syllables in length, nor be difficult to pronounce. The designation of W or R item function was then randomly determined for each of the eight pairs in the intrapair list. The interpair list was created by randomly re-pairing the intrapair associates with the restriction that a pair of W and R item associates were not re-paired with another pair of W and R item associates (e.g., KING-PEPPER; SALT-QUEEN).

One control list was constructed by randomly pairing the R items from the IAR list conditions with a set of eight unrelated words selected from the Palermo and Jenkins norms (C1). In a similar manner, the W items from the IAR list conditions were randomly paired with the set of unrelated words to form a second control list (C2).

In order to control for possible idiosyncratic pairings and to allow for greater generality of the results, the item function of each list in the treatment conditions was reversed. Thus within each IAR condition there were two variations of the list while there were four variations in the control list (C1, C2, C3, and C4). Presentation of the different forms of the lists was counterbalanced within each grade level. In addition, each list was presented in four random serial orders to minimize serial position cues. Across the four random orders, a given R item unsystematically appeared twice in the left position and twice in the right position, but within each random serial order four R items appeared in the left position and four appeared in the right position.

Procedure. Prior to the experiment proper, each S received standard VD instructions. In addition, Ss in the intra-and interpair conditions were informed that the VD list consisted of associatively related words and that such information might prove helpful in learning the list. However, the nature of the inter-or intrapair IAR manipulation was not emphasized. To insure comprehension of the instructions, each S received several practice trials with nonexperimental pairs conforming to the nature of the treatment conditions. Following the practice trials, the treatment list was presented.

Both the practice and treatment lists were presented orally in the anticipation method by means of a tape recorder at a 4:4 sec. rate and with an 8 sec. intertrial interval. Practice continued on the experimental list to a criterion of one perfect trial at which time an unpaced free recall (FR) task was administered. In the FR task, the S was asked to remember all the experimental words he could remember regardless of order or item function and to pronounce them to the experimenter. The experimenter recorded each recalled word.

RESULTS

Acquisition. Initial analyses completed for trials and errors to criterion indicated the four control list variations were comparable in difficulty (both ps > .250). Therefore, the two lists which constituted item function change (C3 and C4) were collapsed as were the two original lists (C1 and C2) so that analyses could be completed utilizing the four grades, the three treatment conditions, and the two list sets (original vs. item function change) as main effects.

These analyses showed the lists constituting item function change was clearly more difficult, $F(1,72)=4.23$, $p<.05$, and $F(1,72)=5.77$, $p<.025$ for both trials and errors to criterion, respectively. However, the seriousness of this finding is reduced somewhat by the absence of a grade by lists (both ps<.25) and treatment by lists ($F<1$ for trials; $p>.25$ for errors) interactions as well as the nonsignificant second order interaction (both $F$s<1) in both sets of analyses. Therefore, any analysis contrasting either grades or conditions are not confounded by the unequal difficulty between the two sets of lists.

The means and standard deviations for trials to criterion for each grade level were 6.08 and 2.62 (kindergarten); 4.58 and 1.84 (first); 3.87 and 2.00 (second); 3.96 and 1.40 (third). The means and standard deviations for the number of errors to criterion for each grade level were 14.71 and 8.22 (kindergarten); 9.83 and 4.81 (first); 8.62 and 5.12 (second); and 9.00 and 4.79 (third). The variation among both sets of means was significant $F(3,72)=7.86$ and $F(3,72)=6.47$, (both ps<.005) for trials and errors, respectively. Newman-Keuls comparisons revealed that kindergarteners required additional trials and made more errors than each of the other grade levels (both ps$<.05$). No other comparisons approached significance in either analyses.

The means and standard deviations for trials to criterion for the treatment conditions were 4.06 and 1.83 (control); 3.94 and 1.83 (intrapair); 5.87 and 2.31 (interpair). Similarly, the mean number of errors and standard deviations for the treatment conditions were 9.06 and 4.82 (control); 8.81 and 5.38 (intrapair); and 13.70 and 7.36 (interpair). As predicted by frequency theory, the treatment conditions were not comparable in degree of difficulty, $F(2,72)=11.79$ and $F(2,72)=8.38$ (both ps$<.005$) for trials and errors, respectively. Newman-Keuls comparisons among both sets of means, showed the interpair condition more difficult than the control condition (ps$<.05$). The slight superiority of the intrapair condition relative to the control and interpair conditions did not approach significance on either measure. In addition, the grade by condition interaction was not significant, $F<1$, and $F(6,72)=1.00$, $p>.25$ for trials and errors respectively.

Free Recall. The free recall protocols were first analyzed with the between group main effects corresponding to grades, treatment conditions, and list sets with type of item recalled (W or R) as the within group measure. Significant main effects were found for treatment conditions, $F(2,72)=5.02$ and type of item recalled, $F(1,72)=44.22$, (both ps$<.005$). The grade by treatment condition by list sets interaction was significant, $F(6,72)=2.36$, $p<.05$. A graphical representation of this interaction suggests that the lists which constituted item function change resulted in higher recall scores in the IAR list conditions for all grade levels except the third grade where the original lists yielded higher recall scores. However, neither the grade by list or treatment conditon by list interactions approached significance ($Fs<1$).

The means and standard deviations for the total recall scores were 7.87 and 2.80, 9.72 and 3.19, and 9.87 and 2.85 for the control, intra-and interpair conditions, respectively. The Newman-Keuls test was again employed to make pairwise comparisons among these means. Both the intra-and interpair conditions differed significantly from the control ($ps<.05$) but did not differ from each other. These findings of increased availability of items for recall in the IAR conditions with children replicate the findings reported by Fulkerson and Kausler (1968) with adults. In accord also with the results of Fulkerson and Kausler was the greater availability of R items ($\bar{X}$=5.25, S.D.=1.33) relative to W items ($\bar{X}$=3.90, S.D.=2.22).

The free recall protocols were also examined to determine the incidence of W-R or R-W intrapair recalls (i.e., successive recall of intrapair W and R items). The between group variables were again grades, treatment condition and list sets whereas the direction of intrapair recalls constituted the within group variable. The direction of intrapair recalls was clearly significan $F(1,72)=18.53$, $p<.005$, with R-W recall ($\bar{X}$=1.77, S.D.=1.28) superior to W-R recall ($\bar{X}$=1.06, S.D.=1.18). The grades by list sets by direction of intrapair recall interaction was also significant, $F(3,72)=4.00$, $p<.025$. This result is apparently attributed to the null difference in direction of intrapair recall ($\Sigma\bar{X}$=18) for the list constituting item function change at the kindergarten level and the slight superiority of W-R recall for the original list at the third grade level ($\Sigma\bar{X}$=18 vs.15). R-W recall was superior in the remaining grades by list sets combinations. However, direction of intrapair recalls interacted with treatment conditions, $F(2,72)=6.63$, $p<.005$. The means and standard deviations for W-R recalls were .87 and 1.04

(control); 1.02 and 1.20 (interpair); and 1.28 and 1.22 (intrapair) and for R-W recall the means and standard deviations were 1.25 and 1.39 (control); 1.37 and 1.04 (interpair); and 2.69 and 1.97 (intrapair). The simple main effects completed for these means revealed that R-W recall was superior to W-R recall only within the intrapair condition, $F(1,72)=24.35$, $p<.005$. As a matter of fact, Newman-Keuls tests indicated that the incidence of R-W recalls in the intrapair condition was superior to both the interpair and control conditions ($ps<.01$). These latter two conditions did not differ from each other. In addition, the incidence of W-R recall was constant across all conditions. The remaining sources of variation were all non-significant.

## DISCUSSION

The pronounced difficulty of the interpair condition relative to both the intrapair and control conditions was amply demonstrated in the acquisition analyses. No differences were revealed between the latter two conditions. These results, in addition to replicating the findings reported by Eberlein and Raskin (1968) and Fulkerson and Kausler (1968), represent an extension of these findings to a population of children. Thus, acquisition performance in the treatment conditions did not interact with grade levels as predicted by the production deficiency hypothesis (Flavell, et al., 1966). According to this hypothesis, children between the ages of five and seven lack the capability to process implicit mediational information in verbal learning tasks (e.g., Jensen and Rohwer, 1965; Moely, Olson, Halwes, and Flavell, 1969). Thus, differences between the treatment conditions, should not become pronounced until the third grade. Since the reported performance in the IAR conditons was characteristic of all grade levels, other processes were apparently operating.

The pronounced difficulty of the interpair condition relative to the control conditions is quite consistent with frequency theory (Ekstrand, et al., 1966), thus suggesting that transfer of IARs did reduce the differential frequency cue. In view of these findings, the null difference between the intrapair and control condition suggests that Ss induce a process to compensate for any reduction in the frequency cue attributed to the transfer of IARs when the intrapair W and R items are associates. One such process may be the tagging procedure postulated by Barch et al., (1967) and supported by Fulkerson and Kausler (1968). This model assumes that Ss can encode an R item and then successively collapse the R item and its associate together to reduce the memory storage load and thus compensate for the reduced frequency cue. This model implies that free recall protocols of the intrapair condition should be characterized by a superiority of R-W recalls relative to W-R recalls since the direction of information processing in acquisition is assumed to favor R-W. Empirical support for this prediction was provided by the fact that superiority of R-W recall to W-R recall was limited to the intrapair condition. As a matter of fact, the incidence of R-W recall was greater in the intrapair condition than in either the interpair or control conditions whereas the incidence of W-R recall was constant across all conditions. In short, the present results provide substantial support for the tagging model. The apparent nonsupport for the production deficiency hypothesis may be due to the sensitivity of VD learning to detect mediation behavior in young children not detected by other verbal learning tasks.

The present results are inconsistent with the interference reported in an intrapair condition by Ahammer and Goulet (1969) for an age spectrum similar to the one employed in the present study. There are, however, two variables which may account for the lack of consistency between the two studies. First, Ahammer and Goulet employed conceptual similarity (e.g., APPLE-BANANA) rather than associative similarity. It is possible the operation of the tagging model may interact with type of similarity, though neither Ahammer and Goulet nor the author of the present study empirically assessed this prediction. Secondly, the mixed list design (i.e., 6 pairs corresponded to an intrapair manipulation whereas the remaining 6 pairs were unrelated) employed by Ahammer and Goulet may have prevented any attempts by the S to efficiently tag and collapse related items.

Finally, the difficulty of the VD task for kindergarteners relative to the first, second, and third grade Ss should also be noted. Other VD studies, although not employing kindergarten Ss (e.g., Ahammer and Goulet, 1968; Bauer, 1967) have reported an invariant relationship between rate of learning and grades one through six, and grades four, six, and eight, respectively. These findings suggests the transition in the rate of recognition-discrimination learning occurs between kindergarten and the first grade whereas studies concerned with the PA learning of children (Cole and Kanak, 1970; Kausler and Gotway, in press) have reported the transition in the rate of associtive learning occurring between the third and fourth grades.

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# APPENDICES

## Appendix A

### Dissertation Prospectus

Recently, a discrimination task has been introduced into human learning research. Prior to this time, the bulk of human learning research employed either a serial learning or paired-associate (PA) learning task. The discrimination procedure has actually been employed in animal research for quite some time, but has only recently gained popularity among human learning investigators. In human learning experiments, the discrimination is usually between two verbal units which have been randomly designated as wrong (W) and right (R) items by the experimenter. The S's task is to select and pronounce the R item of each pair during the initial exposure. Immediately following this anticipation interval, the two items are again presented in juxtaposition with the R item underlined. The latter exposure is the feedback interval which informs the S about the correctness of his selection.

Ekstrand, Wallace, and Underwood (1966) postulated that Ss utilize as a cue for VD learning a subjective assessment of the differential frequency of W and R items. It is assumed that during each anticipation exposure representational responses (RRs; the covert response of perceiving the W and R items) add at least one frequency unit to each item. When the S selects and overtly pronounces one of the items, the pronunciational response (PR) is assumed to add another frequency unit to that item. A correct selection results in a 1:2 frequency ratio in favor of the R item, whereas an incorrect selection yields a 2:1 frequency ratio in favor of the W item. Based upon initial chance levels of responding, it would be impossible for the S to learn the list unless other mechanisms are invoked. Consequently, frequency theory assumes that S rehearses-the-correct-item (RCR) at least once during the feedback exposure.

In the case of an incorrect selection, an RCR should produce a 2:2 frequency ratio and thus the S has a 50% chance of selecting the R item on the subsequent trial. An RCR, in addition to a correct selection, serves to further increase the differential frequency cue (1:3). The emission of RCRs has been reported by Dominowski (1966). Dominowski found that an incorrect selection on the first trial does not necessarily produce adverse effects upon subsequent learning trials, nor does a correct selection always facilitate later performance. Actually, a correct selection played a facilitative role only when both items appeared in the feedback exposure. One implication of these findings is that VD learning is not a one-trial learning phenomena (Saltz, 1964).

Manipulation of frequency unit accrual to the W and R items should either hinder or facilitate performance on a VD task whenever such manipulation reduces or increases, respectively, the magnitude of the differential frequency cue. One such procedure is to require an additional PR to the W item during the feedback interval to reduce the frequency ratio from the conventional 1:3 to a more difficult 2:3. Empirical support for this prediction is presented by Kausler and Sardello (1967) and Sardello and Kausler (1967). Conversely, the magnitude of the differential frequency cue can be increased resulting in faster learning. Ekstrand *et al*. employed implicit associative responses (IARs; Bousfield, Whitmarsh, and Danick, 1958) to investigate the effect of increasing as well as the effect of decreasing the differential frequency cue upon VD learning. Essentially, IARs refer to the occurrence of an implicit associative response elicited by the presentation of a meaningful word. For example, it is assumed that presentation of the word "table" elicits the implicit response "chair" (i.e., the highest associate to "table"). "Chair", therefore receives an additional frequency unit if it occurs elsewhere in the list. If the associative strength is bidirectional the reciprocal process should also occur.

Ekstrand et al. employed a list condition in which pairs of R items were associatively related (AR condition) thereby increasing the frequency ratio (1:4). Another list condition consisted of pairs of associatively related W items (AW condition) which reduced the frequency ratio (2:3). These authors found that the AR and AW conditions were superior and inferior, respectively, to a control list of unrelated words and the conventional 1:3 frequency ratio.

Kanak, Cole, and Thornton (1970) attempted to replicate Ekstrand et al. results and to extend the IAR manipulation to include a condition in which pairs of W and pairs of R items were associatively related (AW-AR condition). The only support for frequency theory, reported by these authors, was the equality between the AW-AR condition and the control condition. As a matter of fact, the results of the AW and AR conditions were exactly opposite to frequency theory and the results of Ekstrand et al. As pointed out by Kanak et al., these discrepancies may be the product of meaningful words, item function and pairing interacting with other factors influencing IARs in VD learning.

Presentation rate is another variable which Ekstrand et al. proposed to influence VD learning. Specifically, the frequency theory predicts an interaction between rate of VD learning and exposure rates of the anticipation and feedback intervals. Increasing the exposure rate of the anticipation interval may result in additional RRs to the W items with a resultant decrement in learning. On the other hand, increasing the exposure rate of the feedback interval should facilitate learning via the opportunity for additional RCRs. Only one study has been concerned with presentation rates

(Kanak, 1968) although rate of exposure was not factorially combined with type of interval. Instead, Kanak employed 1:1, 2:2, and 4:4 sec. exposure rates and found, as expected, the faster rate to interfere with VD learning. The latter two groups did not differ from one another. Thus, Kanak pointed out, the additional time for RCRs in the 4:4 sec. group must have compensated for the additional RRs occurring to the W items.

In yet another prediction of frequency theory, Postman (1962) and Berkowitz (1968) found that a list composed of high frequency items was more difficult to learn than a list made up of low frequency items. This result is expected, according to Weber's Law, in that the addition of one frequency unit is more noticeable when the list is composed of low frequency pairs instead of high frequency pairs. Additional support for this hypothesis was provided by Underwood and Freund (1970) who found that pairs of high experimentally induced frequency were more difficult to learn than low frequency pairs. As the result of these findings, Underwood and Freund suggest that Ss will look for other attributes to serve as cues for discrimination when the differential frequency becomes inadequate. Other studies (Runquist and Freeman, 1960; Schulz and Hopkins, 1968), however, have reported dissonant results.

According to frequency theory, VD learning should also become increasingly more difficult as physical intralist similarity increases. Ekstrand et al. pointed out that with high intralist similarity Ss are likely to confuse RRs, PRs, and RCRs made to one item with those to another item. Several studies (Underwood and Viterna, 1951; Underwood and Archer, 1955; Battig and Bracket, 1963; Yelen, 1969) have demonstrated this effect. Interference due to manipulation of similarity has also been reported in VD procedures other than the conventional two-choice situation. Edwards (1966) found that high similarity in a four-choice task had adverse effects upon the rate of learning.

Frequency theory also attempts to explain the manner in which learning one VD list effects subsequent performance on a second VD list. As a matter of fact, Ekstrand _et al_. originally postulated the frequency theory to account for the transfer data reported by Underwood, Jesse, and Ekstrand, (1964) and then realized its applicability to single-list learning.

In one of the earliest transfer studies, McClelland (1942) found positive transfer whenever the second list retained either the correct or incorrect items from list one and paired these old items with new items. This procedure and results were essentially replicated by Underwood, Jesse, and Ekstrand (1964), although these authors fully informed the _S_ concerning the nature of the second list.

Ekstrand _et al_. proposed that whenever the second list is characterized by R items from the first list paired with new W items (W1-R1, W2-R1) the _S_ should initially respond by selecting the most frequent item (Rule 1). Whenever the W items of the two lists are identical, but paired with new R items in the second list (W1-R1, W1-R2) the _S_ should now select the least frequent item (Rule 2). Positive transfer is therefore attributed to the utilization of the appropriate rule. Of course, the above explanations are relative to a control condition in which the second list is characterized by W and R items unrelated to list one (W1-R1, W2-R2; hereafter only the second list notation will be used), thus neither rule is initially applicable. A strict interpretation of frequency theory predicts that with continued practice on the W1-R2 list, the initial frequency difference in favor of the W items breaks down because of the more rapid accrual of frequency units to the R items. After several trials, the total number of frequency units to the W and R items become nearly equal and thus a deterioration in VD performance is expected, since neither rule can be successfully applied, followed by a return to Rule 1 usage.

A number of studies (Kausler and Dean, 1967; Kausler, Fulkerson, and Eschenbrenner, 1967; Kanak and Dean, 1969) have failed to find positive transfer in the W1-R2 paradigm when Ss are not aware of the nature of the second list. Since the W1-R2 paradigm is analogous to the classical paired-associate A-B, A-C negative transfer paradigm the presence of negative transfer has been attributed to the associative interference from list one (Kausler, et al., 1967). In support of this interpretation, Raskin, Boice, Rubel, and Clark (1968) minimized associative interference by creating a second list in which the item function of List 1 W and R items was reversed. These authors reported positive transfer even though the Ss were not informed about the relationship between the two lists. As pointed out by Kanak and Dean, associative interference in VD transfer increases R latencies instead of producing overt intrusions, but the end result appears to be the same. The effects of associative interference in Rule 1 paradigms is apparently minimal since positive transfer has been amply demonstrated (Kausler and Dean, 1967; Kanak and Dean, 1969) without informing the S about the content of List two.

It should be pointed out that the above discussion is quite consistent with transfer in PA tasks. The W1-R2 and W2-R1 are forward and backward associative interference paradigms, respectively. Several PA studies (e.g., Goulet and Barclay, 1965) have shown that forward associations are a more potent source of interference than backward associations.

Other studies (Kausler and Dean, 1967; Raskin et al., 1968; Kanak and Dean, 1969; Kausler and Olson, 1969) have been concerned with the transfer of IARs. In this situation, the W and/or R items of the two lists enter into an associative relationship so that during list one practice frequency units are accruing to their associates in list two. In general, the results have supported frequency theory, although Raskin et al. pointed out the need for instructions concerning the nature of the IAR relationship. It should be noted that Kanak and Dean (1969) used associative relatedness of W and R items as a substitute for similarity and successively extended Osgood's (1949) first two transfer laws to a VD task.

In an elaboration and extension of frequency theory, Kausler (1966) presented a multiple-component-process theory which conceives VD learning as involving incidental components in addition to the intentional R item recognition. Thus, VD learning can be viewed as a variant of the Type II incidental learning paradigm (McLaughlin, 1965). The incidental components consist of learning the W and R items as "responses" as well as the acquisition of specific W-R and R-W associations. The incidental learning of the four components has been demonstrated by Kausler and Sardello (1967) and Sardello and Kausler (1967). These authors found that W and R item learning increased with continued practice on the VD list and that additional W item learning occurred as the result of requiring an extra PR to these items during the feedback exposure. This latter result is also consistent with frequency theory since the additional PR increases the absolute number of frequency units to the W items, thereby making them more available for recall. The frequency theory should also predict more R item learning than W item learning as measured by various recall tasks since the accumulation of frequency units to the R items exceed that to the W items. Several studies (Keppel, 1966; Kanak and Curtis, in press) have reported the predicted asymmetrical learning.

In short, there is ample evidence reporting the acquisition of specific associations during the course of VD learning. Furthermore, it is possible these associations may serve as cues for acquisition when the subjective frequency difference is no longer adequate. To test this hypothesis, Kausler and Boka (1968) employed a double function list in which the items making up the list served as both W and R items in different pairs. Frequency theory predicts that VD learning, under these conditions, is virtually impossible. Although, Kausler and Boka found VD learning to be very difficult, some learning did occur after many trials which indicates the Ss may have used specific intrapair associations as learning aids.

Child Literature.

Verbal discrimination learning in children has received very little empirical attention. Only two studies (Bauer, 1967; Ahammer and Goulet, 1969) have implications for developmental trends in VD learning. Bauer studied both the intentional and incidental components across an age spectrum including fourth, sixth, and eighth graders. Intentional learning did not vary across these grades which, as Bauer pointed out, may reflect an unequal familiarity with the meaningful words used to construct the VD list. If the older Ss were indeed more familiar with the material, the task may have been initially more difficult as explained by Weber's Law. It has been previously noted that the Weber's Law phenomena exists in the adult literature (Underwood and Freund, 1970). Finally, W-R recall was superior to R-W recall at grades six and eight, but symmetrical learning was demonstrated at the fourth grade level. Consistent with Bauer's work, Ahammer and Goulet (1960) also reported an invariant relationship between rate of intentional learning and grades one through six, nor did intentional learning interact with type of verbal reinforcement.

Goulet and Hoyer (1969) were concerned with the effects of overt PRs made to the W and R items in the VD learning of fifth graders and college undergraduates. In accordance with frequency theory and previous research (Kausler and Sardello, 1967; Sardello and Kausler, 1967) the additional PRs retarded the rate of acquisition, relative to the conventional anticipation procedure. In another study concerned with the effects of PRs, Goulet (1969) employed nursery school children and required the additional PRs to both items prior to the selection of the R item. In contrast to the frequency theory, this procedure did not influence the rate of learning but the positive transfer in the W1-R2 pairs was consistent with Rule 2 responding of frequency theory. The use of a mixed transfer list, however, may have produced confusion concerning application of the appropriate rule for the control pairs, thus the positive transfer may, in part, be artifactual. Goulet also found that relearning of list one was not affected by practice on the W1-R2 pairs as reported by Eschenbrenner (1969) for adult Ss. On the basis of these results, Goulet concluded that frequency theory does not account for VD learning of nursery school children.

The Present Experiment.

The present experiment was concerned with both VD learning and the mediating capability of children. As previously discussed, frequency theory predicts that meaningful words elicit IARs which add frequency units to the appropriate item thereby either increasing or decreasing R item frequency relative to the W item. Whenever two associatively related words are either paired (intrapair condition) or repaired (interpair condition), frequency theory predicts retarded learning rates relative to a control list of unrelated words. The empirical results have been equivocal.

Barch, Lippman, and Whalen (1967) using fourth, fifth, and sixth graders found that an intrapair list was actually easier to learn than the control list. These authors did not employ an interpair condition. Barch et al. suggested that Ss either tags or encodes an item as correct on the presentation trials and then attempts to collapse the pair and its tag together to reduce the necessary storage load. In contrast, Palermo and Ullrich (1968) found the intrapair condition, in accord with frequency theory, to be more difficult than the control condition for both fourth graders and college undergraduates. Similar findings have been reported by Ahammer and Goulet (1969) for grades one through six.

On the other hand, Eberlein and Raskin (1968) and Fulkerson and Kausler (1968) using college Ss found the intrapair and control conditions to be equal in difficulty. In addition, but consistent with frequency theory, an interpair condition was more difficult to learn than the control list. Both sets of authors emphasized the tagging model, as proposed by Barch et al. to account for the null difference between the control and intrapair conditions. As Fulkerson and Kausler pointed out, if this model is operative then, at recall, the S needs only to recall the R item to increase the availability of the W item. As predicted, Fulkerson and Kausler reported a higher incidence of W-R tagging during recall in the intrapair condition relative to the interpair condition.

The disparity in the reported performance in an intrapair condition may be due, in part, to the mode and/or type of presentation. Barch et al. employed an oral presentation of the study-test procedure and found that the intrapair manipulation facilitated learning whereas the utilization of a visual presentation of the anticipation method either produced no effect (Eberlein and Raskin, 1968; Fulkerson and Kausler, 1968) or interference (Palermo and Ullrich, 1968; Ahammer and Goulet, 1969).

It is conceivable that performance in the intra-and interpair conditions may interact with age if it can be assumed that implicit processes active in the presence of IAR manipulations are analogous to the mediational processes in PA learning tasks. Mediation in this context refers to an implicit response interceding between an external stimulus and an overt response. Since the nature of the two implicit responses are similar, the phenomena of PA mediation should extend directly to an IAR manipulation in a VD task.

In regard to mediation in PA learning, Kendler, Kendler, and Wells (1960) noted that there is a stage in human development in which the child apparently does not use implicit mediators even though they are available. The inability of children to spontaneously produce and use mediators as learning aids has been called the production deficiency hypothesis (Flavell, Beach, and Chinsky, 1966). This hypothesis is to be distinguished from the earlier mediation deficiency hypothesis (Reese, 1962) which asserts that a child may evoke a mediator but not use it to assist learning in the expected manner. It may then be expected that the ability to produce and use mediators as learning aids increases with age. A series of studies of by Pavio and his associates (e.g., Pavio and Yuille, 1966; Pavio, Yuille, and Smythe, 1966) provide suggestive evidence for this contention. In each of these studies, the PA learning of concrete nouns was easier than abstract nouns. The concrete nouns were interpreted to evoke sensory images which mediated response recall. This effect appeared to increase with age. Other studies have made more direct tests of the production and mediation deficiency hypotheses. In terms of nonverbal tasks, Corsini, Pick, and Flavell (1968) reported an increase in the spontaneous use of mediators with age. Specifically, Corsini et al. found that more first graders than kindergarteners produced mediators in a nonverbal reproductive recall task. In addition, kindergarten Ss required stronger suggestions to produce mediators than did first graders. Corsini et al. interpreted these results as favorable to the production deficiency hypothesis. Support for the mediational hypothesis has also been reported in a wide variety of nonverbal tasks (Kendler, Kendler, and Wells, 1960; Wiess, 1954; Reese, 1961).

In reference to verbal learning tasks, Moely, Olson, Halwes, and Flavell (1969) concluded that production deficiency characterized the mediation behavior of young Ss. These authors found that kindergarteners, first, and second graders did not categorize objects during recall as did fifth grade Ss. Other studies (Jensen and Rohwer, 1965; Keeney, Cannizzo, and Flavell, 1967) have reported similar findings. The increase in the use of mediators as learning aids beyond the second grade level (Jensen and Rohwer, 1965; Palermo, 1962) is also consistent with the production deficiency hypothesis.

The present experiment therefore selected Ss from kindergarten, first, second, and third grades to practice on one of three list conditions (interpair, intrapair, or control). Taking into account the above data, it is conceivable that the effects of IARs in the inter-and intrapair conditions may not show up until the third grade. However, frequency theory predicts retarded learning rates in both the IAR conditions at all grade levels relative to the control condition, but if Ss utilize the tagging process (Barch et al.) the interpair condition may be the only condition inferior to the control. Finally, the present experiment was not designed as a stringent test of the production vs. mediation deficiency hypotheses. Nevertheless, equality among the list conditions would be suggestive evidence for the production deficiency hypothesis since the "mediator" is present elsewhere in the list.

Method.

Subjects. The 96 students who served in the experiment were selected from the kindergarten, first, second, and third grades (n=24) in the University School. Each S was randomly assigned one of the three experimental conditions upon appearance at the laboratory. It should also be noted, the University School is affiliated with the University of Oklahoma, therefore, the findings of the present experiment only generalize to a similar population.

Word Lists. To construct an 8 pair list in which the intrapair W and R items were associates, 6 primary words and their highest associates were selected from the Palermo and Jenkins (1966) norms. An attempt was made to select word pairs which had high bidirectional associative strength, although only two pairs could be selected to meet this requirement. It was therefore assumed the four remaining pairs met this requirement since normative values for bidirectional strengths were not available. In addition, two pairs (King-Queen; Salt-Pepper) had to be added which were not included in the Palermo and Jenkins norms. The additional restrictions imposed were that each word selected could not be over two syllables in length, nor difficult to pronounce. After selecting the 8 pairs of related items, a randomization procedure was then used to determine the W and R items for the intrapair condition. The interpair list was created by randomly re-pairing the intrapair associates with the restriction that a pair of W and

R item associates were not repaired with another pair of W and R item associates (e.g., King-Pepper; Salt-Queen).

The control lists were constructed by randomly pairing the R items from the IAR list conditions with a set of unrelated words selected from the Palermo and Jenkins norms. In a similar manner, the W items from the IAR list conditions were randomly paired with the set of unrelated words to form a second control list.

In order to control for possible idiosyncratic pairings and for greater generality of the results, the item function of each list in the experimental conditions was reversed thereby creating another set of lists. Presentation of the different forms of the lists was counterbalanced within each grade level. In addition, each list was presented in four random serial orders to eliminate position cues. Across the four random orders, a given R item appeared twice in the left position and twice in the right position, but within each random serial order four R items appeared in the left position and four appeared in the right position.

Procedure. Prior to the experiment proper, each S received standard VD instructions. In addition, Ss in the intra-and interpair conditions were informed that the VD list consisted of associatively related words, although the specific IAR manipulation was not emphasized. These Ss were also informed they may find this relationship helpful in learning the list. To insure comprehension of the instructions, each S received several practice trials with nonexperimental pairs conforming to the experimental conditions. Following the practice trials, the experimental list was presented.

Both the practice and experimental lists were presented orally by means of a tape recorder at a 4:4 sec. anticipation rate and an 8 sec. intertrial interval. Practice continued on the experimental list to a criterion of one perfect trial at which time an unpaced free recall (FR) task was administered. In the FR task, the S was asked to remember all the experimental words he could remember regardless of order or item function and pronounce them to the experimenter. The experimenter recorded each recalled word.

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## Appendix B

### Word Lists

| Control | | | | Interpair | | Intrapair | |
|---|---|---|---|---|---|---|---|
| Thread | Man | Chair | Dogs | Cars | Woman | Soft | Hard |
| Fast | Spider | Thread | Queen | Soft | King | Man | Woman |
| Doors | Cats | Hard | White | Slow | Pepper | Trucks | Cars |
| Cars | Fruit | City | Slow | Cats | Trucks | Cats | Dogs |
| Eagle | Spider | Salt | Long | Web | Fast | Salt | Pepper |
| City | Soft | Woman | Doors | Salt | Queen | Web | Spider |
| Pepper | Chair | Trucks | Eagle | Hard | Spider | King | Queen |
| King | Long | Fruit | Web | Man | Dogs | Fast | Slow |

## Appendix C

### Instructions

### Control List

We are going to play a game with words. The lady's voice on the tape will pronounce two words and then I want you to pronounce to me the word you think is the right word. There is nothing really right about this word, as I just want you to be able to recognize it as the right word and pronounce it to me. After you select the right word, the lady's voice will inform you which is the right word. Of course the first time you hear the two words you will not know which word is right, therefore you must guess but on the succeeding trials, the right word will become more familiar to you and you will be able to select correctly.

First we will go through a few practice trials and then answer any questions. After the practice trials we will practice on another list until we get all the pairs correct at least once.

Instructions

IAR Lists

We are going to play a game with words. The lady's voice on the tape will pronounce two words and then I want you to pronounce to me the word you think is the right word. There is nothing really right about this word, as I just want you to be able to recognize it as the right word and pronounce it to me. After you select the right word, the lady's voice will inform you which is the right word. Of course the first time you hear the two words you will not know which word is right, therefore you must guess but on the succeeding trials, the right word will become more familiar to you and you will be able to select correctly. In addition, you will find the words are related in some way. For example, fingers and hands are related, aren't they, as they are both parts of the body. You may find this relationship helpful in learning the list.

First we will go through a few practice trials and then answer any questions. After the practice trials we will practice on another list until we get all the pairs correct at least once.

## Appendix D

### Kindergarten Raw Data

### Kindergarten Control

| Criterion | | Free Recall | | Tagging | |
|---|---|---|---|---|---|
| Trials | Errors | W | R | W-R | R-W |
| 5 | 15 | 6 | 6 | 3 | 1 |
| 3 | 6 | 5 | 7 | 2 | 3 |
| 5 | 8 | 0 | 6 | 0 | 0 |
| 2 | 4 | 0 | 3 | 0 | 0 |
| 6 | 12 | 0 | 4 | 0 | 0 |
| 5 | 12 | 5 | 5 | 0 | 4 |
| 9 | 22 | 0 | 5 | 0 | 0 |
| 7 | 14 | 2 | 4 | 1 | 1 |
| $\bar{X}$=5.25 | 11.62 | 2.25 | 5.00 | .75 | 1.12 |
| SD=2.19 | 5.70 | 2.66 | 1.31 | 1.17 | 1.55 |

### Kindergarten Interpair

| Criterion | | Free Recall | | Tagging | |
|---|---|---|---|---|---|
| Trials | Errors | W | R | W-R | R-W |
| 10 | 22 | 3 | 3 | 0 | 1 |
| 4 | 8 | 2 | 4 | 0 | 1 |
| 7 | 19 | 3 | 5 | 1 | 0 |
| 7 | 15 | 5 | 6 | 1 | 2 |
| 12 | 37 | 7 | 6 | 3 | 1 |
| 8 | 25 | 6 | 6 | 4 | 2 |
| 8 | 24 | 4 | 5 | 2 | 1 |
| 6 | 13 | 5 | 4 | 0 | 0 |
| $\bar{X}$=7.75 | 20.37 | 4.37 | 4.87 | 1.37 | 1.00 |
| SD=2.43 | 8.88 | 1.68 | 1.13 | 1.51 | .71 |

### Kindergarten Intrapair

| Criterion | | Free Recall | | Tagging | |
|---|---|---|---|---|---|
| Trials | Errors | W | R | W-R | R-W |
| 4 | 9 | 6 | 6 | 0 | 6 |
| 7 | 15 | 4 | 4 | 1 | 3 |
| 4 | 5 | 0 | 5 | 0 | 0 |
| 3 | 10 | 5 | 5 | 3 | 2 |
| 5 | 15 | 5 | 5 | 2 | 3 |
| 11 | 28 | 6 | 6 | 2 | 4 |
| 3 | 5 | 5 | 6 | 1 | 3 |
| 5 | 10 | 6 | 6 | 3 | 3 |
| $\bar{X}$=5.25 | 12.12 | 4.62 | 5.37 | 1.50 | 8.00 |
| SD=2.66 | 7.45 | 1.99 | .74 | 1.19 | 1.69 |

First Grade Raw Data

First Grade Control

| Criterion | | Free Recall | | Tagging | |
|---|---|---|---|---|---|
| Trials | Errors | W | R | W-R | R-W |
| 5 | 8 | 4 | 4 | 2 | 2 |
| 2 | 6 | 1 | 5 | 0 | 0 |
| 6 | 12 | 3 | 5 | 1 | 0 |
| 4 | 11 | 5 | 5 | 1 | 3 |
| 3 | 7 | 3 | 4 | 0 | 0 |
| 5 | 12 | 3 | 5 | 0 | 0 |
| 3 | 11 | 4 | 4 | 2 | 1 |
| 6 | 11 | 3 | 3 | 1 | 1 |
| $\bar{X}$=4.25 | 9.75 | 3.25 | 4.37 | .87 | .87 |
| SD=1.49 | 2.37 | 1.17 | .74 | .84 | 1.13 |

First Grade Interpair

| Criterion | | Free Recall | | Tagging | |
|---|---|---|---|---|---|
| Trials | Errors | W | R | W-R | R-W |
| 3 | 3 | 5 | 3 | 0 | 3 |
| 8 | 19 | 4 | 3 | 1 | 2 |
| 6 | 13 | 5 | 6 | 0 | 2 |
| 2 | 3 | 4 | 4 | 2 | 1 |
| 7 | 14 | 1 | 5 | 0 | 0 |
| 7 | 16 | 4 | 4 | 2 | 2 |
| 7 | 18 | 5 | 7 | 0 | 0 |
| 5 | 8 | 0 | 7 | 0 | 0 |
| $\bar{X}$=5.62 | 11.74 | 3.50 | 4.87 | .62 | 1.25 |
| SD=2.13 | 6.36 | 1.93 | 1.64 | .92 | 1.17 |

First Grade Intrapair

| Criterion | | Free Recall | | Tagging | |
|---|---|---|---|---|---|
| Trials | Errors | W | R | W-R | R-W |
| 3 | 8 | 0 | 7 | 0 | 0 |
| 4 | 7 | 4 | 4 | 1 | 1 |
| 5 | 9 | 6 | 6 | 1 | 5 |
| 2 | 5 | 7 | 7 | 3 | 4 |
| 4 | 5 | 7 | 7 | 1 | 6 |
| 3 | 5 | 0 | 5 | 0 | 0 |
| 3 | 6 | 6 | 6 | 1 | 5 |
| 7 | 19 | 8 | 8 | 3 | 5 |
| $\bar{X}$=3.85 | 8.00 | 4.75 | 6.25 | 1.25 | 3.25 |
| SD=1.55 | 4.69 | 3.15 | 1.28 | 1.17 | 2.49 |

Second Grade Raw Data

Second Grade Control

| Criterion Trials | Errors | Free Recall W | Free Recall R | Tagging W-R | Tagging R-W |
|---|---|---|---|---|---|
| 4 | 7 | 0 | 5 | 0 | 0 |
| 2 | 5 | 2 | 3 | 0 | 1 |
| 4 | 9 | 5 | 6 | 3 | 2 |
| 2 | 3 | 0 | 3 | 0 | 0 |
| 3 | 8 | 4 | 5 | 0 | 4 |
| 6 | 11 | 5 | 4 | 0 | 4 |
| 2 | 4 | 2 | 2 | 0 | 2 |
| 3 | 6 | 3 | 4 | 0 | 2 |
| $\bar{X}$=3.25 | 6.62 | 2.62 | 4.00 | .37 | 1.87 |
| SD=1.39 | 2.67 | 1.99 | 1.31 | 1.06 | 1.55 |

Second Grade Interpair

| Criterion Trials | Errors | Free Recall W | Free Recall R | Tagging W-R | Tagging R-W |
|---|---|---|---|---|---|
| 6 | 18 | 4 | 6 | 1 | 1 |
| 3 | 5 | 7 | 6 | 1 | 2 |
| 3 | 6 | 6 | 6 | 1 | 2 |
| 6 | 12 | 2 | 3 | 0 | 2 |
| 6 | 14 | 6 | 6 | 3 | 3 |
| 10 | 25 | 8 | 8 | 4 | 2 |
| 4 | 12 | 5 | 6 | 1 | 1 |
| 7 | 11 | 2 | 5 | 0 | 1 |
| $\bar{X}$=5.62 | 12.87 | 5.00 | 5.75 | 1.37 | 1.75 |
| SD=2.32 | 6.42 | 2.20 | 1.39 | 1.41 | .71 |

Second Grade Intrapair

| Criterion Trials | Errors | Free Recall W | Free Recall R | Tagging W-R | Tagging R-W |
|---|---|---|---|---|---|
| 3 | 6 | 6 | 6 | 2 | 4 |
| 4 | 12 | 0 | 6 | 0 | 0 |
| 3 | 7 | 7 | 7 | 3 | 4 |
| 2 | 5 | 2 | 5 | 1 | 0 |
| 2 | 3 | 0 | 5 | 0 | 0 |
| 2 | 7 | 4 | 4 | 2 | 2 |
| 3 | 5 | 4 | 5 | 0 | 1 |
| 3 | 6 | 1 | 5 | 0 | 1 |
| $\bar{X}$=2.75 | 6.37 | 3.00 | 5.37 | 1.00 | 1.50 |
| SD=.71 | 2.61 | 2.67 | .92 | 1.19 | 1.69 |

# Third Grade Raw Data

## Third Grade Control

| Criterion Trials | Errors | Free Recall W | Free Recall R | Tagging W-R | Tagging R-W |
|---|---|---|---|---|---|
| 2 | 4 | 2 | 5 | 0 | 0 |
| 2 | 3 | 4 | 6 | 1 | 0 |
| 3 | 11 | 1 | 6 | 1 | 0 |
| 5 | 11 | 7 | 5 | 2 | 3 |
| 2 | 3 | 4 | 7 | 2 | 0 |
| 7 | 22 | 4 | 5 | 3 | 1 |
| 4 | 8 | 6 | 7 | 2 | 2 |
| 3 | 4 | 6 | 5 | 1 | 3 |
| $\bar{X}$=3.50 | 8.25 | 4.25 | 5.75 | 1.50 | 1.12 |
| SD=1.77 | 6.50 | 2.05 | .88 | .93 | 1.36 |

## Third Grade Interpair

| Criterion Trials | Errors | Free Recall W | Free Recall R | Tagging W-R | Tagging R-W |
|---|---|---|---|---|---|
| 4 | 9 | 6 | 7 | 0 | 0 |
| 6 | 11 | 6 | 7 | 2 | 2 |
| 6 | 9 | 5 | 6 | 1 | 1 |
| 5 | 10 | 6 | 8 | 1 | 1 |
| 3 | 10 | 5 | 5 | 0 | 3 |
| 5 | 16 | 3 | 4 | 0 | 1 |
| 3 | 8 | 6 | 8 | 2 | 4 |
| 4 | 7 | 1 | 6 | 1 | 0 |
| $\bar{X}$=4.50 | 10.00 | 4.75 | 6.37 | .75 | 1.50 |
| SD=1.19 | 2.72 | 1.83 | 1.41 | .88 | 1.41 |

## Third Grade Intrapair

| Criterion Trials | Errors | Free Recall W | Free Recall R | Tagging W-R | Tagging R-W |
|---|---|---|---|---|---|
| 6 | 14 | 1 | 5 | 0 | 0 |
| 3 | 5 | 5 | 5 | 3 | 2 |
| 5 | 10 | 8 | 8 | 4 | 4 |
| 4 | 10 | 5 | 5 | 1 | 4 |
| 4 | 5 | 5 | 5 | 0 | 5 |
| 3 | 17 | 4 | 4 | 2 | 2 |
| 3 | 3 | 5 | 5 | 0 | 5 |
| 3 | 6 | 3 | 3 | 1 | 2 |
| $\bar{X}$=3.87 | 8.75 | 4.50 | 5.00 | 4.37 | 1.37 |
| SD=1.13 | 4.89 | 2.00 | 1.41 | 2.26 | 1.51 |

## Appendix E

### Summary Table for the Analyses of Variance

Summary of the 4X3X2 Analysis of Variance
for Trials to Criteron

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Grades (A) | 75.25 | 3 | 25.08 | 7.86 | <.005 |
| Treatment Conditions (B) | 75.25 | 2 | 37.62 | 11.79 | <.005 |
| List Sets (C) | 13.50 | 1 | 13.50 | 4.25 | <.05 |
| AXB | 13.50 | 6 | 2.25 | <1 | |
| AXC | 20.08 | 3 | 6.69 | 2.10 | <.250 |
| BXC | 4.75 | 2 | 2.37 | <1 | |
| AXBXC | 16.67 | 6 | 2.78 | <1 | |
| Error | 229.50 | 72 | 3.19 | | |

Summary of the 4X3X2 Analysis of Variance
for Errors to Criterion

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Grades (A) | 573.91 | 3 | 191.30 | 6.47 | <.005 |
| Treatment Conditions(B) | 495.08 | 2 | 247.54 | 8.38 | <.005 |
| List Sets (C) | 170.66 | 1 | 170.66 | 5.77 | <.025 |
| AXB | 177.59 | 6 | 29.60 | 1.00 | >.250 |
| AXC | 147.59 | 3 | 49.20 | 1.67 | <.250 |
| BXC | 72.34 | 2 | 36.17 | 1.22 | >.250 |
| AXBXC | 30.66 | 6 | 5.11 | <1 | |
| Error | 2126.00 | 72 | 29.53 | | |

Summary of the 4X3X2X2 Mixed Analysis
of Variance for Free Recall

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Between Ss | 449.33 | 95 | | | |
| Grades (A) | 18.77 | 3 | 6.26 | 1.59 | <.250 |
| Treatment Conditions (B) | 39.59 | 2 | 19.79 | 5.02 | <.005 |
| List Sets (C) | 1.50 | 1 | 1.50 | <1 | |
| AXB | 40.91 | 6 | 6.82 | 1.73 | <.250 |
| AXC | 4.93 | 3 | 1.64 | <1 | |
| BXC | 3.96 | 2 | 1.98 | <1 | |
| AXBXC | 55.79 | 6 | 9.30 | 2.36 | <.005 |
| Ss within Gp. | | | | | |
| Error (between) | 283.88 | 72 | 3.94 | | |
| Within Ss | 277.50 | 96 | | | |
| Recall (D) | 86.67 | 1 | 86.67 | 44.22 | <.005 |
| AXD | .51 | 3 | .17 | <1 | |
| BXD | 3.23 | 2 | 1.61 | <1 | |
| CXD | .14 | 1 | .14 | <1 | |
| AXCXD | 3.06 | 3 | 1.02 | <1 | |
| AXBXD | 18.27 | 6 | 3.04 | 1.55 | <.250 |
| BXCXD | 4.18 | 2 | 2.09 | 1.07 | >.250 |
| AXBXCXD | 20.57 | 6 | 3.43 | 1.75 | <.250 |
| DXSs within Gp. | | | | | |
| Error (within) | 140.87 | 72 | 1.96 | | |

Summary of the 4X3X2X2 Mixed Analyses of Variance
for Direction of Intrapair Recalls

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Between Ss | 249.67 | 95 | | | |
| Grades (A) | 1.54 | 3 | .51 | <1 | |
| Treatment Conditions (B) | 31.58 | 2 | 15.79 | 6.63 | <.005 |
| List Sets (C) | .75 | 1 | .75 | <1 | |
| AXB | 15.17 | 6 | 2.53 | 1.06 | >.250 |
| AXC | 1.39 | 3 | .46 | <1 | |
| BXC | .21 | 2 | .10 | <1 | |
| AXBXC | 27.04 | 6 | 4.51 | 1.89 | <.100 |
| S within Gp. | | | | | |
| Error (between) | 172.00 | 72 | 2.38 | | |
| Within Ss | 167.00 | 96 | | | |
| Direction (D) | 24.09 | 1 | 24.09 | 18.53 | <.005 |
| AXD | .96 | 3 | .32 | <1 | |
| BXD | 11.69 | 2 | 5.84 | 4.49 | <.025 |
| CXD | .00 | 1 | | | |
| AXCXD | 14.89 | 6 | 2.48 | 1.91 | <.10 |
| AXBXD | 15.62 | 3 | 5.21 | 4.00 | <.025 |
| BXCXD | 4.60 | 2 | 2.30 | 1.77 | <.250 |
| AXBXCXD | 1.62 | 6 | .27 | <1 | |
| DXSs within Gp. | | | | | |
| Error (within) | 93.50 | 72 | 1.30 | | |