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# MULTIPLE STIMULUS ISOLATION IN PAIRED-ASSOCIATE LEARNING: A TEST OF INTRALIST INTERFERENCE THEORY AND THE REHEARSAL-TIME HYPOTHESIS

VERNON PAUL PATTERSON

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MULTIPLE STIMULUS ISOLATION IN  
PAIRED-ASSOCIATE LEARNING: A TEST OF  
INTRALIST INTERFERENCE THEORY AND THE  
REHEARSAL-TIME HYPOTHESIS

by

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B.A., University of Maine, 1968

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ABSTRACT

MULTIPLE STIMULUS ISOLATION IN  
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## ABSTRACT

The stimulus items of two pairs of bigrams were isolated by the same method of isolation (Color/Color or Tone/Tone) or were isolated by different methods of isolation (Color/Tone or Tone/Color) within an eight-pair, paired-associate list. The study was conducted to determine what effect, if any, isolated material has on the learning rate of the homogeneous, nonisolated list material and also to investigate whether the magnitude of the isolation effect is affected differentially by the same method of isolation and different methods of isolation.

The stimuli were isolated either by printing them in red or sounding a tone throughout their period of presentation. Control lists were used which were duplicates of the experimental lists but contained no isolated material. From the basic list of eight pairs, four pairs were designated as critical pairs. Two of the critical pairs were isolated in any specific list condition, and these isolated pairs appeared as nonisolated pairs in other list conditions. The experiment ran for 24 anticipation learning trials, the memory drum being stopped to obtain a measure of free recall of response items after every four trials.

The study produced no evidence for an effect of isolated material on the learning rate of the nonisolated pairs in the list. Evidence was obtained for an isolation

effect on the isolated pairs under both the same method of isolation and different methods of isolation, but there was a consistent indication that different methods of isolation produced a stronger isolation effect. Several predictions derived from intralist interference theory and the rehearsal-time hypothesis were evaluated. While neither theoretical position accounts fully for the results obtained, there was stronger evidence in support of intralist interference theory. It was concluded that multiple isolation effects in paired-associate learning are specific to the material that is isolated; nonisolated pairs appear to be unaffected by the presence of two isolated pairs. It was also concluded that the same method of isolation produces weaker multiple isolation effects than does the use of different methods of isolation.

## CHAPTER 1

### INTRODUCTION

Since the early experiments of Calkins (1896), Van Buskirk (1932), and von Restorff (1933), there has been substantial research interest in the phenomenon labelled the von Restorff effect. The von Restorff effect refers to the consistent finding that when a unique item is inserted into a homogeneous list of items, it is learned more rapidly than nonisolated items. The considerable amount of research concerning the von Restorff effect has yet to produce, however, a totally convincing theoretical explanation of the phenomenon. Wallace (1965), for example, ends his comprehensive review article by stating: "At the theoretical level, the von Restorff phenomenon remains a controversial one. It may be that a combination of theories will be necessary to explain it adequately." Hall (1971), six years later writes: "In summary, and in keeping with Wallace's (1965) position, there is not yet an adequate theory to explain the von Restorff phenomenon."

Although the von Restorff phenomenon has been demonstrated in both the serial learning and paired-associate learning paradigms, comparisons of the effect demonstrated within each paradigm seem inappropriate since the procedures and demands on the subjects are very different. Therefore,

a conservative approach will be taken here and the results from each paradigm will be treated separately.

Most of the paired-associate and serial learning research related to the von Restorff effect has been stimulated by three theoretical viewpoints.

The first studies of von Restorff (1933) were done to provide empirical support for Gestalt theory. The Gestalt explanation for the faster learning of the isolate is based on the perceptual principle of figure-ground relationships inherent in the structure of the learning materials. When an item is made different or "isolated" from otherwise homogeneous list material, it can be conceived of as a figure. The homogeneous items are conceived of as ground. In memory, the traces of the homogeneous items lose many of their distinctive characteristics as they merge to become the ground. The memory trace of the isolated item then comes to stand out distinctively as the figure on the ground provided by the merged traces of the homogeneous items.

An alternative theoretical approach has come from the basic work of Gibson (1940, 1942). The fundamental constructs of Gibson's approach were stimulus generalization and differentiation. Generalization refers to:

[T]he tendency for a response  $R_a$  learned to  $S_a$  to occur when  $S_b$  (with which it has not been previously associated) is presented. A generalization gradient is said to be formed when a number of stimulus items show decreasing degrees of generalization with a given standard stimulus. The hypothesis need make no assumption as to the type of stimulus continuum

which will yield a generalization gradient, but it is consistent with it to suppose that such a gradient will be yielded by a group of stimuli which can be arranged along any dimension or scale with respect to the presence of some discriminable quality or aspect-- in other words, stimuli which would be considered to vary in degree of similarity [Gibson, 1940, p. 204] .

Differentiation refers to:

A progressive decrease in generalization as a result of reinforced practice with  $S_a \rightarrow R_a$  and unreinforced presentation of  $S_b$  [Gibson, 1940, p. 205].

As well as the above definitions, two of Gibson's (1940)

Propositions are particularly relevant to the von Restorff effect. These two propositions are IV:

If multiple generalization occurs during the learning of a list, and if the list is constituted so that the generalizing items have different responses, an increasing number of repetitions will be required to reach a given criterion of learning as the strength of the generalizing tendencies increases [Gibson, 1940, p. 211].

and VI:

A stimulus-response pair which is a member of a list containing other stimulus items having a strong tendency to generalize with it will require more repetitions to be learned than would the same pair as a member of a list whose stimulus items have a low tendency to generalize with it [Gibson, 1940, p. 213] .

This approach, extended by Newman and Saltz (1958), suggests that the more similar or homogeneous the items in the list, the more stimulus or response generalization will occur. This generalization would then interfere with correct responding by producing greater intralist interference. An isolated item is easily differentiated from the homogeneous items, hence there is less intralist interference to the isolate as a result of reduced stimulus or response generalization.

This relative decrease in intralist interference leads to the rapid learning of the isolate.

A third explanation of the von Restorff phenomenon has to do with the attention-getting or orienting value of the isolated item. First suggested as an explanation by Jenkins and Postman (1948), it was later adopted by Green (1958a; 1958b) after he first considered an explanation based on the notion of "surprise" (Green, 1956). Initially somewhat vague in terms of the mechanism underlying an attention model explanation, this stance has recently been elaborated by Waugh (1969). According to Waugh, not only is a novel item selectively attended to (held in the mind longer) but also this selective attention allows selective rehearsal. The added rehearsal leads to the better retention of the isolated item compared to a nonconspicuous and less rehearsed control item. As a result of this selective rehearsal of the unique item, some other item(s) in the list must be ignored.

One of the first questions to arise after the demonstration of the von Restorff effect was, what is the effect of isolating an item on the other items in that list? Relative to this question there will follow separate brief reviews of the research in the serial and paired-associate learning paradigms. Beginning the serial learning section, the three theoretical approaches previously considered are elaborated in order to examine the predictions they make concerning the learning rates of nonisolated list



material.

### Serial Learning

The Gestalt view postulates that the homogeneous material becomes the ground on which the trace of the unique item stands out as a figure. Extrapolating to a list of homogeneous items, one would predict no figure-ground relationship among the items. It is difficult to make a precise prediction based on the notion of ground as to what the traces of the comparable homogeneous items in an experimental and control list would be like. It seems that in the control list situation there is simply one more trace to become merged into the ground. It also may be that any one homogeneous item in the control list becomes the figure due to some perceived idiosyncrasy of that item as perceived by each subject. In either case, a specific differential prediction of the learning or recall rates of the homogeneous items in an experimental list versus the comparable items in a control list seems unwarranted, or at best, tenuous. Gestalt theory seems primarily amenable to explaining the faster learning of the isolate in figure-ground terms and not directly concerned with the learning rates of the non-isolated material.

Intralist interference theory (Gibson, 1940, 1942; Newman and Saltz, 1958) however, makes very specific predictions concerning the isolate's effect on other members of the list as well as predicting the isolation

effect itself. These predictions are as follows:

Prediction 1. The isolated term will occur more frequently as a correct response than will a non-isolated term occupying the same serial position.

Prediction 2. The isolated term will occur less frequently as an overt intrusion than will its non-isolated counterpart.

Prediction 3. More correct responses will be made to an isolated term as a stimulus than to a nonisolated term occupying the same serial position.

Prediction 4. Total errors during learning of isolated lists will be fewer than for nonisolated lists, even when the isolated terms as stimuli and as responses are not considered (Newman and Saltz, 1958, p. 469-470).

Prediction 1 was based on the concept of response generalization. Since the isolate as a response is dissimilar from the other list items as responses, it should be less amenable to the inappropriate elicitation of other list items in its place due to the decrease in inter-item generalization. Obviously, this decrease in response generalization would not occur to the corresponding control item occupying the same serial position. Prediction 2 was also based on the concept of response generalization. Since the isolated item enjoys a decrease in response generalization, not only should other list items not compete with it as a response but also it should not compete with the other list items.

In other words it should not be elicited inappropriately as a response due to the relative decrease in response generalization and should not appear frequently as an overt intrusion error. Prediction 3 was based on the concept of stimulus generalization. If one assumes that the functional stimulus for the item following the isolate is the isolate itself, then it follows that if the isolate enjoys a reduction in interference resulting from stimulus differentiation, its response will be facilitated. Prediction 4 was based on the concepts of stimulus and response generalization. They felt that isolating an item leads to both a reduction in stimulus and response generalization of that item. Since the isolate is clearly differentiated from the other items in the list, there will, in effect be a reduction in the intralist competition throughout an isolated list. It is of interest to note that predictions 3 and 4 were not substantiated in the Newman and Saltz (1958) study.

The attention-model explanation makes predictions directly opposite to intralist interference theory. If we assume that the attention model is correct, selective rehearsal of the isolate leads to its better retention at the expense of other items in the list. More errors would be expected, then, to the nonisolated items in the experimental list than to nonisolated items occupying the same serial position in the control list. Jenkins and Postman (1948) also suggested that the number of errors

to the item following the isolate would be greater than the number of errors to an item occupying the same serial position in a control list since it is not unreasonable to assume that it is during the following item's presentation that the rehearsal of the isolate is occurring.

Since the initial question posed was, what is the effect of isolating an item on the other items in the list, an examination of relevant serial learning research follows. Jones and Jones (1942), in an attempt to answer this question, used a list of ten nonsense syllables with the seventh syllable in red. They found that the isolated seventh item was learned significantly faster than the critical control list item. The learning curves presented in the Jones and Jones (1942) study also suggested a slight facilitation effect for the items on either side of the isolate; however, this difference was not verified by statistical analysis. There was no advantage in terms of number of trials to criterion for the list containing the isolate over the control list. Smith (1949) had subjects recall serial lists after one presentation and found an isolation effect for an item printed in red, but there seemed to be no effect on the total number of items recalled when the experimental list was compared to the control list. Smith and Stearns (1949) found that when the eighth item in a serial list of adjectives was isolated by color it was learned more rapidly than its control list counterpart. Smith and Stearns also suggest that the

ninth item in the experimental list was facilitated compared to its control, but again the experimental list did not enjoy any learning advantage over the control list. Other studies that show an isolation effect but no advantage of the experimental list over the control list include Jenkins and Postman (1948), Kimble and Dufort (1955), Newman and Saltz (1958), Jensen (1962), Roberts (1962), McLaughlin (1966) and Cimbalo (1969). The only study which shows an advantage of the experimental list over the control list was one by Raskin, Hattle and Rubel (1967). It is interesting to note that the method of isolation was presentation of electric shock. Raskin et al. suggest that previous methods of isolation (meaningfulness, color, etc.) were too weak to facilitate overall list learning.

With the exception of the Raskin et al. (1967) study, the results from the previously mentioned studies are in general agreement that a list containing an isolated item is not learned more rapidly than a homogeneous list. In terms of the effects of isolating an item on the preceding and following items the results are mixed. Studies suggesting a facilitating effect on the preceding items, succeeding items or both include those by Jones and Jones (1942), Smith (1948), Smith and Stearns (1949), McLaughlin (1966) and Raskin et al. (1967). Jenkins and Postman (1948), Smith (1949), Jensen (1962), Roberts (1962) and Cimbalo (1969) have conducted studies which show no facili-

tation of items preceeding or following an isolate as well as no list facilitation. These inconclusive and contradictory findings have made it difficult for any one theoretical explanation of the von Restorff effect to be adequate.

In summary, the support for intralist interference theory comes from the suggestion that the item following the isolate is facilitated in the Jones and Jones (1942) and the Smith and Stearns (1949) studies. The only empirical support, however, comes from the studies by McLaughlin (1966) and Raskin et al. (1967). The only empirical evidence for overall list facilitation is again to be found in the Raskin et al. (1967) study.

The major source of support for the rehearsal-time hypothesis comes from the general finding of the majority of isolation studies that there are no differences between the list learning rates of isolated and nonisolated lists. The attention-model explanation suggests that since there are no differences in list learning rates between isolated and nonisolated lists and since the isolate is learned significantly faster than its control list comparison, the nonisolated items in the isolated list must be learned more slowly than their control list counterparts. However, the studies that show no differences in list learning rates do not show any adverse effects in terms of number of errors to any of the nonisolated items in the experimental list, with the exception of the Jenkins and Postman (1948) study. Thus, the main support for the attention model is

based on accepting the null hypothesis. Perhaps rather than stating that the isolate is learned faster than its control to the detriment of the other items in the list, it would be more accurate to state that list learning rates appear to be unaffected by the presence or absence of an isolated item. This last statement reflects the conclusion drawn by Bruce and Gaines (1976) in a recent examination of the von Restorff effect. In their Experiment IV they were directly concerned with the issue of whether or not isolated items in a list affect other items in the list. None, one, two or four critical, categorically related, nouns were isolated within a list of 20 noncritical words. For half of the lists the noncritical words were common unrelated concrete nouns. For the other half of the lists the noncritical items consisted of five sets of four categorically related concrete nouns. Bruce and Gaines were particularly interested in looking at the recall rates for the four critical items when only one or two of them were isolated to see if the von Restorff effect would spread to the other critical related nonisolated items. They concluded: "...any beneficial effects produced by perceptual isolation are fairly item specific and do not extend appreciably to words which are related but not isolated." As well as being unable to find any "spread of effect" for perceptual isolation Bruce and Gaines were also unable to demonstrate any negative effects relative to noncritical list items. The empirical support for

either intralist interference theory or the rehearsal-time hypothesis is not very impressive.

It seems that empirically speaking, both the list facilitation explanation and the rehearsal-time hypothesis are on shaky ground. What is needed is a precise demonstration of either facilitation or negative consequences for the nonisolated items in an isolated list. A demonstration of a significant difference between the error rates for nonisolated items in an isolated list and the appropriate comparison items in a control list is necessary if the explanatory power of either theoretical position is to be enhanced.

One possible way of resolving this impasse is with multiple-item isolation. The classic result of multiple-item isolation was demonstrated by Pillsbury and Raush (1943). As they increased the number of isolates relative to the massed material, they found a nearly monotonic decrease in the advantage of the disparate material over the massed material. That the von Restorff effect would be diminished with multiple-item isolation is not surprising, since with multiple-item isolation the disparate items become increasingly massed themselves when the same method of isolation is used.

Roberts (1962) suggested that perhaps the decrease in intralist generalization provided by one isolate was simply not great enough to result in list effects. Roberts hypothesized that isolating multiple items (3) in a 15 item



list might decrease generalization to the point where list differences could be detected. His results were not supportive of an interference explanation. He did find a multiple isolation effect when high meaningful-value items (Noble, 1952) were isolated in a list of low meaningful-value items. The number of errors to the nonisolated items in the isolated list was greater, although the difference was not statistically significant, than the number of errors to the control list comparison items.

#### Paired-Associate Learning

Paired-associate learning studies have been less concerned with the effect of the isolated pair on the other items in the list than have the serial learning studies. Many studies (Erickson, 1965, 1968, 1974; Kimble and Dufort, 1955; Nachmias, Gleitman and McKenna, 1961; Newman, 1965, 1975; Newman and Forsyth, 1965, and Patterson, (1974) have been concerned with comparing stimulus versus response isolation. The most consistent findings are that isolating either a stimulus or a response results in an isolation effect on the critical pair, and that stimulus isolation produces a greater effect than response isolation. In the Erickson (1965, 1968, 1974); Kimble and Dufort (1955); Nachmias, Gleitman and McKenna (1961); and Patterson (1974) studies there is no chance to compare the nonisolated items in the experimental list with the nonisolated items in a control list since in these studies there are no

control lists where none of the pairs is isolated. The Newman (1965, 1975) and Newman and Forsyth (1965) studies do have a control list that allows the comparison of the number of correct responses to the nonisolated pairs in an experimental list to the number of correct responses to the nonisolated pairs in a control list. The comparisons made, however, only involve the number of correct responses made to the critical isolated pair and its appropriate control. The Newman (1965) and Newman and Forsyth (1965) studies do report the mean number of correct responses to the isolated pair and the mean number of total correct responses for both experimental and control conditions. In Newman's (1965) Experiment I, for example, he reports a mean number of correct responses for the stimulus-isolated pair of 11.53. The mean number of correct responses to the control list pair is 7.8. Newman also reports the mean number of total correct responses for each condition. The mean number of total correct responses in the stimulus isolated condition is 148.73. The mean number of total correct responses for the control condition is 139.07. From these data it can be calculated that there were 4.5% more correct responses to the nonisolated pairs in the experimental condition than to the nonisolated pairs in the control condition. This same calculation can be made on the data presented in the Newman and Forsyth (1965) study. In this study there were 3.6% more correct responses to the nonisolated pairs in the experimental

(stimulus isolated) condition than to the nonisolated pairs in the control condition. Although there is not enough information presented in these two studies to do a statistical analysis of the data, they do suggest what might be a small but consistent advantage in learning for the nonisolated pairs in the stimulus isolated condition. These two studies also supply a methodology where it is possible to study the effect of an isolated pair on the other pairs in the list. In both the Newman (1965) and Newman and Forsyth (1965) studies, a study-test procedure was used for 15 trials.

The Newman (1975) study utilized the paired-associate paradigm with one study trial. This study also used response isolation rather than stimulus isolation for the critical pair. In this study, response isolation did not affect the number of correct responses to the nonisolated pairs in the experimental condition relative to the number of correct responses to the nonisolated pairs in the control condition. This is not a surprising finding, however, since one-trial learning was used and the isolated pair was presented eighth in a list of 14 pairs. It would seem that this methodology would minimize any possible effect the isolated pair could have on the other pairs in the list. It is also of interest to note that if an isolated pair's effect on the learning rates of the nonisolated pairs is related to the magnitude of the isolation effect, it should be recalled that response isolation produces a smaller effect than stimulus isolation.

## CHAPTER II

## OBJECTIVES OF PRESENT RESEARCH

There are two basic questions to be addressed by the present research. First, will isolating the stimuli of two pairs of bigrams in paired-associate learning influence the learning rates of the homogeneous pairs in the list? Second, when the stimuli of two bigram pairs are isolated within a list, does the number of errors to either pair change as a result of the stimuli being isolated by the same or different methods? The rehearsal-time hypothesis and intralist interference theory suggest the following predictions regarding the above questions.

If two stimulus items in a paired-associate list are isolated, the rehearsal-time hypothesis would predict that the isolated pairs would enjoy more overt or covert rehearsal time than their controls and that they would therefore be learned more rapidly, to the detriment of the nonisolated pairs in the list. Intralist interference theory would predict that the interference due to stimulus generalization would be decreased by the two isolated pairs and both isolated pairs would be learned more rapidly than their control list comparisons. Also, since the number of massed pairs has been decreased, the nonisolated pairs

should also enjoy a decrease in interitem interference. This decrease should lead to the faster learning of the nonisolated experimental list pairs, compared to their appropriate controls.

Isolating two stimulus items by the same method of isolation versus isolating two stimulus items by different methods of isolation would also yield different predictions by the two theoretical positions in question. When two pairs are isolated either by the same or different methods of isolation, they should, in both cases, be equally conspicuous relative to the homogeneous pairs. As conspicuous pairs, they would be selectively rehearsed and recalled according to the rehearsal-time hypothesis. From the intra-list interference position, however, when two pairs are isolated by the same method there should be some interference between them. The resulting isolation effect should be smaller in magnitude than the isolation effect produced by isolating two pairs by different methods. An experiment that empirically tested these divergent predictions would help resolve the issue of the effect of isolated elements on the other elements in the list. Such an experiment would also determine whether any differential isolation effects of multiple isolation are produced when the method of isolation is made different rather than the same for two pairs of items.

## CHAPTER III

## METHOD

Materials and Apparatus

Four basic control lists of eight consonant bigram pairs were used. These lists are shown in Table 1. In the four experimental versions of list A, the critical pairs SD-GK and PC-NR were isolated respectively in the following ways: color/color, color/tone, tone/color and tone/tone. These four combinations of isolation techniques were repeated across lists B, C and D. The only difference between list A and list B was which critical pair was presented first on the first trial. In list A it was SD-GK and in list B it was PC-NR. The same difference held for lists C and D. In list C, MB-RV was the first critical pair presented and in list D, VM-LF was the first critical pair presented. On the initial trial, the critical pair appearing first was always in the fourth position. On the initial trial, the second isolated pair was either in position 7 or position 8. The tone used to isolate items had a frequency of 1000 hertz and a decibel level of 40 determined by a General Radio sound level meter calibrated at .0002 dynes per square centimeter. The tone was generated by a 200cd model Hewitt-Packard audio oscillator and delivered to the S through Superex Sensiphone earphones.

Table 1  
The Basic Lists

A	B	C	D
MB-RV	MB-RV	*MB-RV	*MB-RV
CN-TL	CN-TL	CN-TL	CN-TL
*SD-GK	*SD-GK	SD-GK	SD-GK
HG-BJ	HG-BJ	HG-BJ	HG-BJ
VM-LF	VM-LF	*VM-LF	*VM-LF
FP-DH	FP-DH	FP-DH	FP-DH
*PC-NR	*PC-NR	PC-NR	PC-NR
KS-JT	KS-JT	KS-JT	KS-JT

\* Isolated pairs

The lists were printed on 80 lb. fotolith paper. The symbols were 11/32 in. in height and appeared in 36 point Clarendon type. Each list appeared on an endless tape in eight different orders with no spaces separating the orders. A Gloric memory drum with a 2-2-1 sec. time sequence and a specially constructed neon light assuring equal illumination of the stimulus and response apertures was used. Each S first was required to learn the following practice list of six pairs of two syllable nouns: ZEBRA-CAPTAIN, WAGON-OFFICE, MONEY-KITCHEN, HEAVEN-DINNER, VILLAGE-GARMENT and INSECT-JEWEL.

#### Design

The basic experimental design was a 2x2x4 factorial design with one control group. The major independent variables were method of isolation at item position four on the initial trial (tone or color), method of isolation for the second isolated pair on the initial trial (same or different than the method at item position four), and list (A, B, C, D). The number of Ss for the control groups was 48 and the number of Ss in the factorial design was 48.

There were six major dependent variables. These were the number of errors to the critical pair isolated first on the initial trial, the number of errors to the critical pair isolated second on the initial trial, the number of errors to the nonisolated pairs (all errors except those to the two isolated pairs), the number of



correct responses during free-recall for the first critical pair isolated, the number of correct free-recall responses for the second critical pair isolated, and the number of correct free-recall responses to the nonisolated pairs.

#### Procedure

Before the experiment began each S was randomly assigned to a specific experimental condition or to one of the control groups.

Each S was initially required to learn the practice task of noun pairs to a criterion of one perfect recitation. Each S was then run on a specific experimental or control list of bigram pairs for a total of 24 trials. The Ss were instructed to spell out their responses which were recorded verbatim by E. The Ss were given six free-recall trials for response items (one free-recall trial after each four consecutive anticipation trials). On the free-recall trials, each S was asked to list as many of the response items as he/she could recall on a blank sheet of paper. When the S indicated that he/she could recall no more response items or when one minute had gone by without an entry, E restarted the memory drum for another four consecutive anticipation trials. The instructions given to each S for anticipation learning and free recall are presented in Appendix A. At the end of the experiment all Ss were debriefed and asked not to discuss the experiment with anyone else.

Subjects

The subjects were 96 undergraduate psychology students at the University of New Hampshire who were fulfilling an introductory psychology course requirement.

## CHAPTER IV

## RESULTS

Anticipation Learning Errors

The first dependent measure analyzed was the number of errors per S per pair during anticipation learning trials. Since there was no consistent serial order after the first trial, the "first isolated pair" refers to that pair isolated first in the list on Trial 1. An analysis of variance performed on the number of errors to this pair and its appropriate control list pair yielded a significant F for the experimental vs. control main effect, F (1,88) = 12.36,  $p < .01$ . This significant main effect shows that the first isolated pair was learned with significantly fewer errors than its control list counterpart and demonstrates an isolation effect at the first isolated position. A comparable ANOVA done on the number of errors per S per pair at the second isolated position (defined on the first trial) only suggests an isolation effect, with F (1,88) = 2.98,  $.10 > p > .05$  for the isolated vs. control pair comparison.

A factorial ANOVA (2x4x2) was carried out on the number of errors per S at the first isolated position within the experimental conditions only. The factors were

Color vs. Tone isolation, Specific Pair isolated first on Trial 1, and Same vs. Different methods of isolation for the two isolated pairs within any one experimental list. The analysis yielded a significant  $F$  for the Same vs. Different effect,  $F(1,32) = 7.73$ ,  $p < .01$ . This finding shows that the first isolated pair was learned significantly faster when the second isolated pair was isolated by a different method than when the second isolated pair was isolated by the same method. The lack of any other significant  $F$ 's for this analysis indicates that no differences were produced by the type of isolation (Color vs. Tone) at the first isolated position or by the Specific Pair that was isolated. The same factorial analysis was done on the number of errors per  $S$  at the second isolated pair within experimental conditions only. The results of this analysis were consonant with the factorial analysis described above. The only significant  $F$  was for the Same vs. Different main effect,  $F(1,32) = 9.95$ ,  $p < .01$ . This shows that there were significantly fewer errors at the second isolated pair when the first pair involved a different method of isolation.

After establishing this consistent effect at both isolated positions, a series of independent analyses was conducted to see if the overall experimental vs. control isolation effects depended upon using different methods of isolation. The ANOVA on the number of errors per  $S$  at the first isolated position when the second isolated pair was

isolated by a different method yielded a significant effect for the Different vs. Control comparison,  $F(1,64) = 18.42$ ,  $p < .01$ . This significant main effect shows that, compared to the errors made to the appropriate control pair, fewer errors were made to the first isolated pair when the second isolated pair was isolated by a different method from the first. This finding demonstrates an isolation effect at the first isolated position under these conditions. The ANOVA on the number of errors per  $\underline{S}$  at the first isolated position when the second isolated pair was isolated by the same method as the first yielded an  $F(1,64) = 2.22$ ,  $p > .10$ . No significant difference was found between the experimental and control errors for this condition. There was no isolation effect at the first isolated position when the second isolated pair was isolated by the same method as the first isolated pair. Therefore, the isolation effect found in the overall experimental vs. control analysis of errors at the first isolated position was a result of the efficacy of the condition using different methods of isolation.

The same independent analyses were done on the number of errors at the second isolated position. The ANOVA on the number of errors per  $\underline{S}$  at the second isolated position when the first isolated pair was isolated by a different method yielded a significant Different vs. Control main effect;  $F(1,64) = 9.30$ ,  $p < .01$ . This finding demonstrates an isolation effect at the second isolated position compared to the control pairs when the first isolated pair

was isolated by a different method of isolation. The ANOVA comparing the number of errors per S at the second isolated position to the control pairs when the method of isolation was the same at both positions yielded an  $F < 1$ . These last two analyses demonstrate that there was an isolation effect at isolated position two only when the first isolated pair was isolated by a different method than that used at isolated position two. Table 2 shows the advantage that different methods of isolation produced at each isolated position, compared to the same method of isolation and to the control condition. Table 3 shows the results of the individual comparisons made at each isolated position.

#### Anticipation Learning Errors/Nonisolated Pairs

The next series of analyses was done on the number of errors to the nonisolated pairs during anticipation learning. The overall analysis comparing the number of errors to the nonisolated pairs in the experimental lists with the appropriate control list pairs yielded no statistically significant differences. The factorial analyses of the number of errors to the nonisolated pairs in the experimental lists also failed to yield any statistically significant differences.

#### Free Recall Scores/Isolated Pairs

Analyses were also carried out on the number of correct responses per S per pair during free recall trials.

TABLE 2

Mean Number of Errors Per S Per Pair  
Over Trials 1-24 For Isolated Pairs in  
Each Isolated Position and Critical Control Pairs

Anticipation Scores			
Position	Isolation by Different method	Isolation by Same method	Control
First Iso- lated Pair	6.0	10.3	13.0
Second Iso- lated Pair	6.3	12.1	11.8

TABLE 3

F Values Obtained in Comparisons Between  
Same vs. Different Conditions and Between Isolated Pairs  
and Appropriate Controls for Each Position

Position	Comparison	<u>F</u> Value
1	Same vs. Different	<u>F</u> (1,32) = 7.73*
	Same vs. Control	<u>F</u> (1,64) = 2.22
	Different vs. Control	<u>F</u> (1,64) = 18.42*
2	Same vs. Different	<u>F</u> (1,32) = 9.95*
	Same vs. Control	<u>F</u> (1,64) < 1
	Different vs. Control	<u>F</u> (1,64) = 9.30*

\* $p < .01$



The experimental versus control comparisons at each isolated position and the experimental factorial analyses yielded no statistically significant differences.

#### Free Recall Scores/Nonisolated Pairs

A series of analyses identical to those done on the anticipation learning errors for nonisolated pairs was done with the number of correct free recall responses per S per pair for the nonisolated pairs. The overall analysis comparing the number of correct free recall responses to the nonisolated pairs in the experimental lists with the appropriate control list pairs yielded no statistically significant differences. The factorial analyses of the number of correct free recall responses to the nonisolated pairs in the experimental lists also failed to yield any statistically significant differences.

#### Intrusion Errors

Since it was established that there were more anticipation errors to the isolated pair at each position when the other isolated pair was isolated by the same method than when it was isolated by a different method, specific intrusions from the item at the other isolated position were analyzed. Intrusions at the first isolated position from the item at the second isolated position were tabulated for both the experimental and control list conditions, as were intrusions at the second isolated position

from the item at the first isolated position. The overall analyses comparing intrusions at each isolated position in the experimental conditions to intrusions in the control condition yielded no significant  $F$ s. The experimental factorial analysis at each isolated position, however, yielded results that were consistent with the findings for anticipation learning scores. The factorial analysis of intrusions at the first isolated position suggested a Same vs. Different main effect,  $F(1,32) = 3.41, .10 > p > .05$ . The same type of analysis done for the second isolated position yielded a significant Same vs. Different main effect,  $F(1,32) = 7.37, p < .025$ .

A series of independent analyses was next carried out, comparing intrusions at each position for the Same and Different conditions independently to the intrusions in the control group. Tables 4 and 5 summarize the intrusion error data. The Same versus Control group comparison at position one yielded a significant main effect,  $F(1,64) = 8.37, p < .01$ . There were significantly more intrusions in the Same group than in the Control group. The Different vs. Control group comparison did not result in any statistically significant differences. Comparing the intrusions at the second isolated position of the Same and Control groups yielded a significant  $F$  for the Same vs. Control main effect,  $F(1,64) = 7.26, p < .01$ . Again, there were significantly more intrusions for the Same group than for the Control group. Comparing the intrusion errors of the

TABLE 4

Mean Number of Response Intrusion Errors at Each Isolated Position  
From the Other Isolated Position Per S Over Trials 1-24  
for Isolated and Critical Control Pairs

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Anticipation Scores			
Position	Isolation by Different methods	Isolation by Same methods	Control
First Iso- lated Pair	.42	.92	.33
Second Iso- lated Pair	.17	1.29	.46

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TABLE 5

Mean Number of Intrusion Errors Per S  
 From Both Isolated Positions Over Trials 1-24  
 At Different Places Within the Experimental  
 and Control Lists

Anticipation Scores			
Place of Intrusion	Isolation by Different Methods	Isolation by Same Method	Control
Other Isolated Pair Only	.30	1.11	.39
Intrusions at Nonisolated Pairs	.87	1.37	1.93
Total List Intrusions	1.17	2.48	2.32

Different and the Control groups at isolated position two yielded an  $F$  that suggests there were fewer errors to the Different group than the Control group,  $F(1,64) = 3.02$ ,  $p > .05$ .

#### Difference Scores (Anticipation Learning)

In an attempt to compare the technique of using a control group as a basis of comparison to a technique using within subject's difference scores, a series of analyses using difference-score measures was done. Using anticipation learning scores, the number of correct responses to the first isolated pair for each subject was multiplied by two (the I score). The total number of correct responses to the two nonisolated critical control items (N) for each  $S$  was subtracted from the I score. The resulting I-N difference score was then used as the experimental dependent variable.

The difference score analysis (Erickson, 1968; Patterson, 1974) for the first isolated position yielded a significant  $F$  for the mean,  $F(1,32) = 19.23$ ,  $p < .01$ . This significant  $F$  for the mean demonstrates an isolation effect. That is, averaged across all experimental conditions, the first isolated pair was learned more rapidly than the critical nonisolated control items. No other significant  $F$ s were found in this analysis.

The same I-N analysis done for the second isolated position yielded a significant  $F$  for the mean,  $F(1,32) =$

9.60,  $p < .01$ . Again, averaged across all experimental conditions the second isolated pair was learned more rapidly than the critical nonisolated control pairs. No other significant  $F$ s were found in this analysis.

#### Difference Scores (Free Recall)

An identical I-N difference score analysis was also carried out on the free recall scores. The ANOVA for the I-N free recall at the first isolated position yielded a significant  $F$  for the mean,  $F(1,32) = 7.22$ ,  $p < .05$ . This significant  $F$  for the mean demonstrates an isolation effect at the first isolated position and shows that averaged across all experimental conditions, the response of the first isolated pair was recalled more frequently than the critical nonisolated control responses. There was also a significant Method of Isolation by Isolated Pair interaction,  $F(3,32) = 6.25$ ,  $p < .05$ . No other major or minor variables or their interaction resulted in a significant  $F$ .

The free recall difference score analysis at the second isolated position, yielded a significant  $F$  for the mean,  $F(1,32) = 13.86$ ,  $p < .01$ . This demonstrates an isolation effect at the second isolated position. No other major or minor variables or their interaction resulted in a significant  $F$ .

#### Mixed ANOVA

Since the difference score analyses did not demon-

strate a significant effect for the Same versus Different conditions, a mixed ANOVA (Treatment by Subjects design) was carried out on the errors to the isolated pairs at each isolated position and the errors to the critical nonisolated control pairs. The mixed ANOVA design was used since difference scores inherently include individual differences in response to individual pairs and therefore the resulting variability among difference scores may be higher than that derived from a repeated measures design. While both the difference score analysis and the mixed ANOVA designs are sensitive to within Ss responding, it was felt that the mixed ANOVA might be more sensitive to between group differences. The within-subjects repeated measures variable was the errors to the isolated pair and the errors to the critical nonisolated pairs during anticipation learning. The between Ss comparison was with Same method of isolation for both isolated pairs or a Different method of isolation for both isolated pairs. At the first isolated position there was a significant between Ss main effect (Same vs. Different),  $F(1,46) = 6.30, p < .05$ . There were significantly fewer errors for the combined I and N pairs at the first isolated position when the method of isolation was different within a list than when it was the same. Since the number of errors to the N pairs was similar under each method of isolation, it can be inferred that the significant difference found resulted primarily from the difference in I pairs relative to each method of isolation. The repeated measures factor

(Isolated vs. Critical Nonisolated Pairs) yielded an  $F(1,46) = 20.87, p < .01$ , which demonstrates an isolation effect at the first isolated position.

The same analysis done at the second isolated position again yielded a Same vs. Different between  $S_s$  main effect  $F(1,46) = 7.80, p < .01$ . There were significantly fewer errors for the combined I and N pairs at the second isolated position when the method of isolation was different within a list than when it was the same. Again, since the number of errors to the N pairs was similar, under each method of isolation this finding can be inferred to be primarily a result of differences between the I pairs relative to each method of isolation. The  $F(1,46) = 15.89, p < .01$  for the repeated measures factor demonstrates an isolation effect. There was also a significant interaction  $F(1,46) = 4.16, p < .05$  between the Same vs. Different between groups variable and Isolated vs. Nonisolated within  $S_s$  variable. Figure 1 shows the mean number of errors per  $S$  to both the Isolated pair and Nonisolated pairs for the Same vs. Different conditions at each Isolated Position.

The mixed ANOVA design was also used to analyze the free-recall scores. At the first isolated position there was a suggestion of a significant between groups (Same vs. Different) main effect,  $F(1,46) = 3.68, .10 > p > .05$ . The  $F(1,46) = 5.11, p < .05$  for the repeated measures factor demonstrates an isolation effect. At the second isolated position, there was a significant between groups main



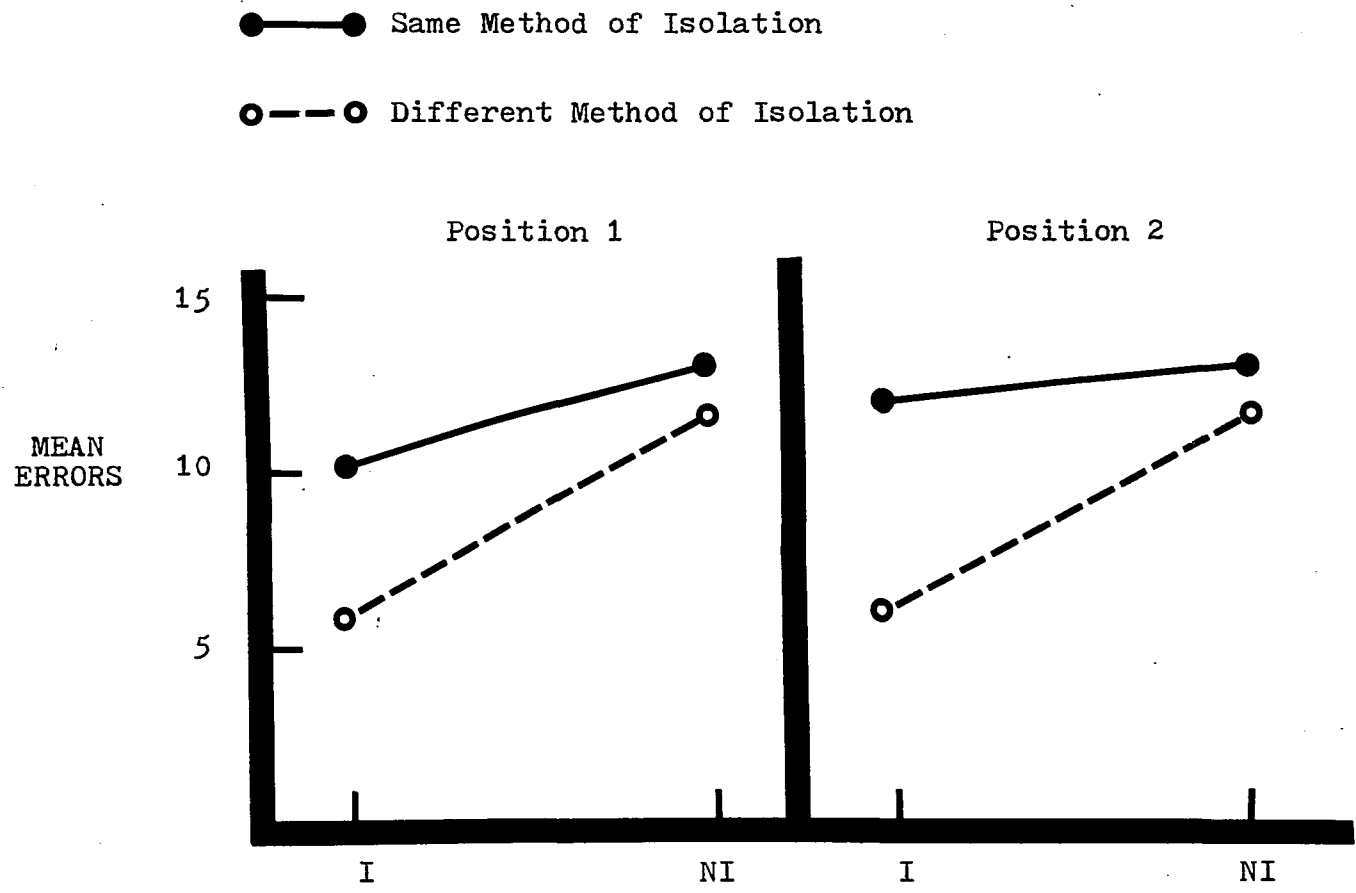


FIG. 1. Mean number of errors per S across the 24 anticipation learning trials to the isolated and nonisolated pairs under the Same vs. Different conditions at each isolated position.

effect,  $F(1,46) = 4.98, p < .05$ . The  $F(1,46) = 13.93, p < .01$  for the repeated measures factor demonstrates an isolation effect.

To check for a position effect, the mixed ANOVA design was used to analyze the anticipation learning scores for errors to the isolated pairs. The between groups factor was Same vs. Different and the repeated measures factor was Position one vs. Position two. There was a significant between groups main effect,  $F(1,46) = 13.08, p < .01$  demonstrating that there were significantly fewer errors to the isolated pairs at either isolated position when the pairs were isolated by different methods rather than the same method. The within  $S_s$  factor (position) did not yield a significant  $F$ , nor was the  $F$  for the interaction significant.

Figure 2 presents information comparing the average number of errors per  $S$  per trial made to the isolated and critical nonisolated pairs. Table 6 summarizes the error data per  $S$  per isolated pairs and critical nonisolated pairs over 24 trials. These data were used in the analyses which used each  $S$  as his own control. In addition to the data presented in Table 6, the mean number of errors per  $S$  for both isolated positions for the critical control list pairs over trials 1-24 was 12.4. The mean number of errors per  $S$  per noncritical control list pairs over trials 1-24 was 12.2. The mean number of errors per  $S$  per pair for

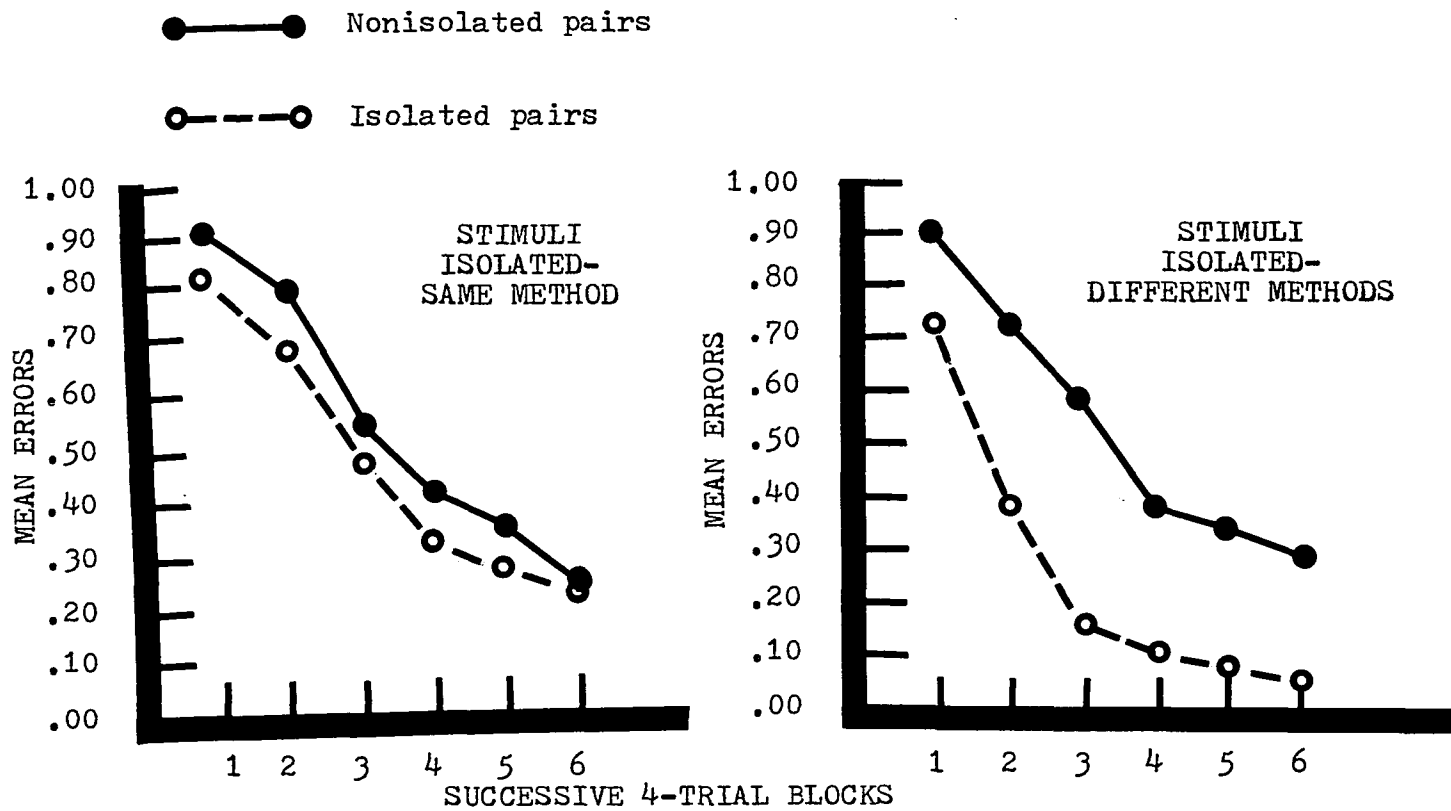


FIG. 2. Mean errors per  $\underline{S}$  per pair per trial made to isolated and critical nonisolated pairs averaged over four-trial blocks for each method of isolation.

TABLE 6

Mean Experimental List Anticipation Learning Errors  
 Per S For Both Isolated Positions Over Trials 1-24  
 For the Same vs. Different Conditions and Isolated  
 and Critical Nonisolated Pairs.

Anticipation Scores		
Stimulus Isolation Conditions	Isolated Pairs	Critical Nonisolated Pairs
Same	11.2	13.8
Different	6.15	11.8

noncritical experimental list pairs over trials 1-24 was  
13.5.

## CHAPTER V

## DISCUSSION

The two basic questions examined in the research were: 1) will isolating the stimuli of two pairs of bigrams in paired-associate learning influence the learning rates of the homogeneous pairs in the list? and 2) when the stimuli of two bigram pairs are isolated within a list, is the learning rate of either pair affected by isolating the stimuli by different methods of isolation rather than the same method?

The investigation provided no evidence that the learning rates of homogeneous pairs in a paired-associate list are affected by isolating the stimuli of two pairs of bigrams. However, the rate of learning the isolated pairs does depend on whether their stimuli are isolated by the same method or different methods of isolation. The details of this finding and their implications will be discussed after presenting a summary of the analyses of scores obtained for each of the dependent variables. In addition, several subsidiary findings of the present study will be discussed.

For the anticipation learning scores, the analyses indicated: (a) When two pairs were isolated within a list

by different methods (color/tone), each pair was learned significantly faster than its comparison pair in a non-isolated control list; (b) when two pairs were isolated within a list by the same method (color/color or tone/tone), their learning rates showed no advantage over the learning rates of their control list comparisons; (c) when two pairs were isolated within a list by different methods, each pair was learned at a faster rate than each of two pairs isolated by the same method; and (d) the learning rate of the nonisolated pairs in the experimental lists showed no advantage over the learning rate for the appropriate control list pairs.

For the free-recall scores, the analyses indicated: (a) The recall of responses of isolated pairs showed no advantage over the recall of the responses of control list comparison pairs at either the first or the second isolated position; (b) the recall of responses of pairs isolated by different methods showed no advantage over the recall of responses isolated by the same method at either the first or second isolated position; (c) there were no significant differences between the recall of responses of nonisolated experimental list pairs and their control list comparison pairs; (d) when free-recall scores were analyzed using within S difference scores, the responses of the isolated pairs were recalled significantly better than critical non-isolated pairs; and (e) when the free-recall scores were analyzed with a mixed ANOVA design there was an isolation

effect, and the number of responses recalled from pairs isolated by different methods of isolation combined with the number of responses recalled from critical nonisolated pairs was significantly higher than the number of responses recalled from pairs isolated by the same method of isolation combined with the number of responses recalled from critical nonisolated pairs.

The intrusion error data indicated that: (a) there were significantly more specific intrusion errors between isolated pairs for the Same group than for the Different group; (b) there were significantly more specific intrusion errors between isolated pairs in the Same group than in the Control group at each isolated position. These various results will now be discussed in terms of the two basic questions addressed in this investigation.

Relative to the two basic questions examined in this research, specific predictions had been derived from intralist interference theory and the rehearsal-time hypothesis. Addressing the first question, the rehearsal-time hypothesis predicts that since the isolated pairs enjoy selective attention and selective rehearsal, the nonisolated pairs in the list will receive diminished attention and rehearsal, and will show a decrease in learning rate when compared to control list pairs. Intralist interference theory makes the opposite prediction. Since the number of massed pairs has been decreased, the nonisolated pairs should enjoy a decrease in intralist interference. This



decrease should lead to the faster learning of the non-isolated experimental list pairs compared to their appropriate controls. The analyses of the anticipation learning scores and of the free recall scores did not reveal any significant differences between the learning or recall rates of the nonisolated experimental list pairs and the control list comparisons. The predictions of neither theoretical point of view were substantiated.

The results of this study show that the presence of isolated pairs within a list had no detectable effect on the learning rates of the nonisolated pairs in the list. In other words, the isolation effect was specific to the pairs isolated in the list. This finding is consistent with the results of the Bruce and Gaines (1976) study, which also tested the rehearsal-time hypothesis.

Relative to the second question, the rehearsal-time hypothesis predicts comparable isolation effects for the Same and Different conditions, since the isolated pairs in question are in both cases conspicuous relative to the homogeneous items. As conspicuous pairs, they should be selectively attended to and rehearsed, resulting in an isolation effect. Intralist interference theory also predicts that both the Same and Different conditions will result in an isolation effect. However, in the Same condition there should be some interference between the two isolated pairs, which would reduce the magnitude of the isolation effect relative to the isolation effect in the

Different condition.

Both the rehearsal-time hypothesis and intralist interference theory predict that the isolated pairs will be learned faster than their control list counterparts. These predictions were substantiated, with one qualification. Isolated pairs were learned significantly faster than control list pairs only when the two isolated pairs were isolated by different techniques. When the two isolated pairs were isolated by the same method, they showed no advantage in learning rate over the control list comparisons. While intralist interference theory predicted a Same vs. Different main effect, which was substantiated, it also predicted that even though the magnitude of the isolation effect would be smaller for the Same condition than the Different condition, the Same condition would result in an isolation effect. This latter prediction was not substantiated, since there was no evidence from anticipation learning scores of an isolation effect for the Same condition. The rehearsal-time hypothesis, however, predicted comparable isolation effects for the Same and Different conditions. This prediction was clearly not substantiated. The failure of the Same condition to produce an isolation effect based on comparisons with the Control group will be discussed more fully later in this section. A Same vs. Different main effect was also found with regard to the intrusion data. There were significantly more specific intrusion errors between isolated pairs for

the Same group than for the Different group.

In the present investigation, when difference scores (obtained in Free Recall) were used as the dependent variable, there was no Same vs. Different main effect. It can be inferred that on the average, regardless of whether the method of isolation was the Same or Different, there is an isolation effect when performance on the isolated pairs is compared to performance on the two critical nonisolated pairs. Since the lack of a Same vs. Different main effect was somewhat surprising, a mixed ANOVA was carried out that treated the I score and the N score as repeated measures. This analysis resulted in an isolation effect at both positions and a Same vs. Different main effect at both positions. While the mixed ANOVA appears to be more sensitive to between-groups differences than the analysis based on difference scores, it is useful to remember that both the Same vs. Different main effect and the combined isolation effect wash out when experimental free-recall scores are compared to the free-recall scores of a separate control group.

An ANOVA based on I-N difference scores was also done for the anticipation learning scores. An isolation effect was detected at each item position and again there was no Same vs. Different main effect. The mixed ANOVA treating the I score and the N score as repeated measures was consistent with the original ANOVA for anticipation learning scores and showed both the isolation effect and

the Same vs. Different main effect at each isolated position. It appears that the analyses based on I-N difference scores are masking or are insensitive to the Same vs. Different main effect found in the other analyses, and may be an inappropriate dependent variable to use when it is important to find between-group differences if they exist.

An unexpected finding of this research was the complete lack of an isolation effect for the Same condition when anticipation learning scores were the dependent measure. Intralist interference predicted that even though the magnitude of the isolation effect would be smaller for the Same condition than the Different condition, the Same condition would result in an isolation effect. The rehearsal-time hypothesis predicted comparable isolation for the Same and Different conditions. There were no significant  $F$ 's at either Position when the Same group was compared to the Control group. This result seems at variance with the results of Pillsbury and Rausch (1943), Roberts (1962) and Waugh (1969). All of these researchers found evidence of multiple isolation effects when the method of isolation was the same. There are some major methodological differences between these studies and the present one. These former studies used a serial learning paradigm; the present study used a paired-associate learning paradigm. Pillsbury and Rausch (1943) and Roberts (1962) used different concentrations of different types of material to produce an isolation effect. Pillsbury and

Rausch varied the density of three-digit numbers and nonsense syllables from one three-digit number and seven nonsense syllables to seven three-digit numbers and one nonsense syllable. Their results showed a fairly monotonic decrease in the advantage of the disparate item(s) over the massed items as the number of disparate items increased from one to four. Roberts (1962) imbedded three low-meaningful items in a list of twelve high-meaningful items and three high-meaningful items in a list of twelve low-meaningful items. Roberts found an isolation effect when the disparate items were the high-meaningful items, but not when the disparate items were low-meaningful items. In Waugh's (1969) study (Experiment I), lists of 24 common monosyllables were used as test stimuli and 1,2,3,4,6,9,12,15 or 18 items were followed by a brief high-pitched tone with instructions to "...attend 'especially to the words followed by a beep' with the intent of retaining them." Subjects were then given standard free-recall instructions. As the number of signalled items increased, there was a fairly monotonic decrease in the advantage of the signalled material over the nonsignalled material. In Waugh's Experiment II the same materials were used, but the free-recall instructions were changed to include instructions to not only " 'pay special attention to every word followed by a beep' but also to 'write these words down first' so as to recall as many of them as possible." Under these conditions, up to four items could be signalled with-

out any decrease in the advantage of the signalled material over the nonsignalled material.

Pillsbury and Rauch's (1934) and Waugh's (1969) findings are based on interpretations from figures presented in their articles and not on statistical analyses. In addition, the serial learning paradigm includes such differences from the paired-associate learning paradigm as a well-defined list beginning and end, constant order effects, and the possibility of each item acting as both a stimulus and response. Comparisons of the findings from that paradigm with the paired-associate paradigm are probably inappropriate, and further research in paired-associate learning is necessary to understand fully multiple isolation effects in that paradigm.

There is some debate as to what becomes the functional stimulus of a pair and what is the nominal stimulus in paired-associate learning. In the present research and in the Patterson (1974) study, both of which used bigrams as pair components, Ss often reported that they had difficulty learning the list until they could generate something meaningful that the letters could stand for. The pair VM-LF might come to mean Vermont-Leaf for an S. This implies that for some Ss the letters stand for meaningful mediators that can be associated and then decoded into the correct response. Another common technique with such material is the use of the first letter of a consonant-vowel-consonant (CVC) as a functional stimulus. Postman and

Greenbloom (1967) have suggested that the first letter of a CVC is most often chosen as the functional stimulus. The concern with the functional component of a nominal stimulus in paired-associate learning is theoretically treated by Martin's (1968) encoding variability hypothesis. According to Martin's hypothesis, stimuli which can be consistently encoded lead to faster learning of a pair than stimuli which can not be consistently encoded. Erickson (1974) has suggested that Martin's encoding variability hypothesis can be used to understand isolation phenomena. When a stimulus item is isolated by color or tone, this added cue can be consistently encoded and therefore leads to the faster formation of an associative bond between the stimulus as encoded and the correct response. Relevant to the present study, it can be argued that for the Different condition each method of isolation (Color or Tone) became the functional stimulus for the pair, resulting in a consistent encoding that led to the rapid formation of an association between each respective isolation cue and the appropriate response. It is suggested that in the Same condition the added cue (method of isolation) led to a consistent encoding and Ss initially attempted to use this stimulus dimension to form an associative bond with the correct response. Subjects could come to know that in the presence of this stimulus cue, one of two responses was called for. The difficulty would be in knowing which response to give. Under the Same condition, it could be expected that there

would be a high degree of specific response intrusions between isolated pairs. Tables 4 and 5 show much higher levels of specific intrusion errors for the Same condition than for either the Different or the Control conditions and statistical analyses demonstrated these differences to be significant. To generate the correct response to an isolated stimulus in the Same condition, the S would have to attend to at least one of the letters in each isolated stimulus bigram. This change in strategy could conceivably reduce performance on isolates in the Same condition to a level closer to the performance on the control list comparisons.

Based on the results of the Erickson (1965, 1968, 1974) and Patterson (1974) studies, it was predicted that an isolation effect would be evidenced in the free-recall scores. This prediction was not substantiated when the number of correct recall responses for the isolated pairs was compared to the number of correct recall responses for the control list comparison pairs. There was also no Same vs. Different main effect based on free-recall scores. When the free-recall data were converted to I-N difference scores and analyzed in the same way as in the Erickson (1965, 1968) and Patterson (1974) studies, there was a consistent isolation effect obtained at both Positions. What this suggests is that the isolation effect produced by multiple methods of stimulus isolation is a weak effect that can only be detected when a derived within-Ss score is the



dependent variable.

Newman (1975) has argued that the isolation effect obtained in free recall of the response terms found in Erickson (1968, Experiment I) was due to the advantage the isolated responses had early in training and that this advantage drops out in the latter half of training. The lack of advantage in the latter half of training for free recall of the isolated response probably reflects a ceiling effect for response recall. The data from the present research suggest that the early advantage in free recall of the response of the isolated pair is only relative to critical nonisolated pairs within any specific S's experimental list. When the comparison is with critical items in a control list, the individual differences found in paired-associate learning, coupled with the random basis for any one particular response item to be recalled consistently and early, leads to a level of variability such that the weak isolation effect in free recall is not evidenced. While the number of isolated responses correctly recalled at both positions (483) was larger than the number of control responses correctly recalled at both positions (422), the magnitude of the difference was not great enough to outweigh a large error term in the statistical analysis. Unfortunately in the Newman (1965) study, where there was a separate control group for each condition, free recall was not tested. In the Newman (1975) study, where isolation effects were found during free recall, there

was only one study trial.

There were two significant interactions in the experiment. The first, based on free-recall scores at the first isolated position, was a Method of Isolation by Isolated Pair interaction. The interaction appears to be based on the pair, PC-NR. When this pair was isolated by color there were fewer correct responses to the isolated pair than to the critical nonisolated pairs. When this pair was isolated by tone, its recall was better than its critical nonisolated pairs. There was no suggestion of this type of interaction on Free-Recall scores at Isolated Position 2 or at either position with any of the other dependent variables. The significant interaction would appear to represent a Type I error.

The second significant interaction was the one for Isolated Position 2. This interaction, which is shown in Figure 1, was between the Same vs. Different between-groups variable and the Isolated vs. Nonisolated within-groups variable. It came from the mixed ANOVA design, which treated the anticipation errors of each S to the isolated pairs and to the critical nonisolated pairs as repeated measure scores. Figure 1 shows that for the Isolated pairs there was a large difference between the errors to pairs isolated by the Same method vs. pairs isolated by Different methods. This is indicative of the Same vs. Different main effect found throughout this experiment. This difference in average errors was reduced however, when the critical non-

isolated pairs were considered. This lack of a large difference in average errors for critical nonisolated pairs regardless of method of isolation (Same or Different) is not surprising. The only way these critical nonisolated pairs could have been affected would have been indirectly since they were not isolated themselves. They were nonisolated pairs and, as such, this interaction is consistent with the overall finding that isolation effects are specific to the isolated pairs. It should be remembered that for any one S the critical nonisolated pairs are technically no different from the other nonisolated pairs in an experimental list. The reason they were chosen as comparison pairs was that in alternate versions of the basic experimental list they were the isolated pairs. In the Patterson (1974) study, the anticipation learning errors to critical nonisolated pairs were compared to the anticipation learning errors to the other nonisolated pairs. There were no statistically significant differences found. Table 6 and the other mean anticipation error rates given in the last paragraph of the Results Section show that the mean error rate to the nonisolated pairs from either the control list or the experimental lists were quite similar.

The aggregate results of this investigation favor intralist interference theory rather than the rehearsal-time hypothesis. The Same vs. Different main effect predicted by intralist interference theory was found in the analyses of anticipation learning errors, specific intrusion

errors between isolated pairs, and free-recall scores of the isolated and critical nonisolated pairs when treated as repeated measures. These findings support intralist interference theory and do not support the rehearsal-time hypothesis.

Neither theoretical point of view was supported by the absence of an isolation effect for the same condition during anticipation learning. Intralist interference theory, since it predicted a diminution of the isolation effect under this condition, garners some support in terms of the direction of the results. However, the complete lack of an isolation effect was not predicted.

The findings relative to the nonisolated pairs in the experimental lists compared to the appropriate control list pairs support neither theory. The rehearsal-time hypothesis predicted more errors to the nonisolated experimental list pairs, while intralist interference theory predicted a reduction of errors to these pairs. The results showed no significant differences between error rates for the nonisolated experimental list pairs compared to their control list counterparts.

Neither the rehearsal-time hypothesis nor intralist interference theory accounts fully for the results obtained in this study. Relevant to the two major questions posed in this research, it appears that the learning rates of the homogeneous experimental list pairs are not affected by the presence of two isolated pairs in the list and the

error rate to the isolated pairs is dependent upon the way (Same vs. Different) in which they are isolated.

Future research with multiple-pair isolation in the paired-associate paradigm is needed. The finding that the learning rate of nonisolated pairs appears to be unaffected by the presence of isolated pairs needs to be verified, since it is not consistent with the predictions made by either intralist interference theory or the rehearsal-time hypothesis. Perhaps the presence of more than two isolated pairs, all isolated by different methods, would result in a demonstrable effect on the nonisolated list members. If the results found here were to be replicated, however, it may be necessary to alter our thinking relative to intralist interference theory and the rehearsal-time hypothesis. Both intralist interference theory and the rehearsal-time hypothesis predicted an effect on the nonisolated experimental list pairs. There was no empirical evidence for such an effect found in this study. It may be that both theoretical positions need to be reworked in terms of generating predictions for the impact of isolated material on other list items in paired-associate learning. It is also possible that one of these theories does predict correctly the effect of isolated material on the homogeneous material contained in the list. The magnitude of the effect, however, may be so small that it defied detection in the learning task used in this study.

Another finding of this research which needs ampli-

fication is the lack of an isolation effect when two pairs were isolated by the same method. This finding was clearly different from the results of research within the serial learning paradigm. The difficulty of the paired-associate learning task, especially with the bigrams used here, may be factors contributing to the lack of an isolation effect when the method of isolation for two pairs is the same. Although isolation effects are relatively easy to produce, a precise explanation for the effect still remains elusive.

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APPENDIX

## APPENDIX 1

## INSTRUCTIONS PRESENTED TO ALL SUBJECTS

Pre-Test Instructions

The apparatus that you see here (pointing) is a memory drum, and I'm going to ask you to learn to associate some pairs of words. When I start the machine, you'll see a word. Immediately afterward, a door will open and you'll see another word. There will be a number of pairs of words exposed in this way, and your task will be to learn which pairs of words go together, so that when you see the first word exposed you'll tell me what the one behind the door is before the door opens. Don't try to learn the pairs in any order, for the order will change from trial to trial. I'll tell you when to begin telling me what the responses are. Don't be afraid to guess and make mistakes; that's how you learn this type of task. OK? (To one errorless trial)

Test Instructions

(Turn off practice drum) All right, fine, (That was good). Now if you will look over here at the other drum (pointing), we'll try exactly the same kind of task, using some two letter syllables rather than words. For these syllables, I'd like you to spell the response, rather than trying to pronounce it. For example, this would be Q-W (E hold up hand-lettered card). It's very important that you pronounce each letter clearly because it's very easy for me to confuse some letters. For example, A and J sound alike, and unless you speak clearly, I might get them confused. This will be a more difficult task than the one you have just completed, so don't be surprised if you find it harder. If you have any questions during the test session, please wait until the session is over before asking them. Again I'll tell you when to begin responding, and also once again, don't be afraid to guess and make mistakes, OK? This time I would also like you to wear these earphones. (To 24 trials)

### First Free-Recall Trial Instructions

(At the end of each four consecutive anticipation learning trials, stop the drum). OK, very good. (Hand S a blank sheet of paper). Now I'd like you to take this pencil and write down as many of the responses as you can remember. That is, just those items that were on the right (E pointing), the ones you have been saying. Feel free to guess. (If S says, "I can't, etc."). Just do the best you can. Write down as many as you can remember. (After S states he can recall no more responses or after one minute without an entry) All right, that's good. Now we'll go back to the machine.

### Other Free-Recall Trial Instructions

(Hand S a blank sheet of paper). OK, I'd like you to again take this pencil and write down as many of the responses as you can remember. Again, feel free to guess. (After S states he can recall no more response items or after one minute without an entry). All right, that's good. Now we'll go back to the machine.