72-3423

PEACOCK, Larry Guy, 1943-
PAIRED-ASSOCIATE TRANSFER AS A FUNCTION
OF ANTICIPATION VERSUS FREE LEARNING.

The University of Oklahoma, Ph.D., 1971
Psychology, experimental

University Microfilms, A XEROX Company, Ann Arbor, Michigan

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

PAIRED-ASSOCIATE TRANSFER AS A FUNCTION OF ANTICIPATION VERSUS FREE LEARNING

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

LARRY G. PEACOCK

Norman, Oklahoma

1971

PAIRED-ASSOCIATE TRANSFER AS A FUNCTION OF

ANTICIPATION VERSUS FREE LEARNING

APPROVED BY

DISSERTATION COMMITTEE

ACKNOWLEDGEMENTS

The author is deeply indebted to Assistant Professor N. Jack Kanak, Chairman, Department of Psychology, University of Oklahoma, for his invaluable help during all phases of the present research. His willingness to share his time and knowledge out of a real concern for his students will not be forgotten.

The author also wishes to extend appreciation to Assistant Professors Vera M. Gatch, Ph.D., John Lamberth, Ph.D., and Paul D. Jacobs, Ph.D., for their critical reading of the dissertation.

The author is also indebted to Kit C. Farwell, Ph.D., Director, Department of Psychology, Central State Griffin Memorial Hospital, for graciously allowing the author time away from his duties at Central State, time without which this dissertation would have been impossible.

Appreciation is also due to Ed Eckert for his knowledge of recent transfer literature; Samuel Bowser for his help with the computer programs; Nancy Curvin for her help in preparing the 1,487 slides used in the study; Robert Morton for his electronic wizardry; and to Marla Hellams for her careful typing of the final manuscript.

A last note of special appreciation is due the author's wife, Susan, for her help with the typing, her encouragement, and most of all, her patience and understanding throughout both the dissertation and my graduate training.

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Manuscript to be submitted for publication.

PAIRED-ASSOCIATE TRANSFER AS A FUNCTION OF ANTICIPATION VERSUS FREE LEARNING

Most studies of paired-associate transfer of training have employed the anticipation (ANT) method of presentation and little is known of the generality of theories of transfer mechanisms beyond the ANT method. Theories concerning transfer mechanisms have, in turn, relied heavily upon the two-stage model (Underwood & Schulz, 1960) of paired-associate learning, a model which assigns major roles to the response item and to associative processes but minimizes the role of the stimulus item and backward associative learning. The two-stage model of response learning and associative learning is itself predicated upon the processes involved in ANT method learning and hence some questions about the generality of transfer processes across methods of presentation simultaneously become questions about the generality of the two-stage model. Martin's (1965) component process analysis of transfer of training, in which response availability, forward associative learning, and backward associative learning are assumed to be the major components of transfer in classical Osgoodian paradigms, may be seen to reflect the dual influence of ANT method processes and the stage analysis conception of paired-associate learning.

Implicit in most theories of transfer in classical paradigms is the assumption that PA learning in the ANT method yields asymmetrical forward and backward associative strength, in contrast to the associative symmetry hypothesis of Asch and Ebenholtz (1962) which holds that bidirectional associations of equal strength are formed. While the evidence for the associative symmetry hypothesis is mixed, the bulk of the literature indicates that asymmetry is closer to the rule than the exception when learning is conducted under the ANT method (Ekstrand, 1966). Asymmetry under the ANT method, however, has been postulated as a performance rather than a learning phenomena by a number of investigators (e.g., Asch & Ebenholtz, 1962; Ekstrand, 1966; Kanak & Neumer, 1970). Kanak & Neumer have demonstrated that methods of PA learning which involve recognition learning of one item of a pair and recall processes for the other item of a pair (e.g., ANT method) do produce asymmetry in bidirectional recall, while methods which involve homogeneous processes during acquisition for both items (i.e., either recognition or recall) result in associative symmetry. Since backward associative learning in the ANT method is frequently weaker than forward learning, transfer paradigms involving backward associative processes typically yield weaker transfer effects than those involving forward processes, the role of response learning notwithstanding. It follows from the results of Kanak and Neumer, however, that methods of acquisition involving homogeneous processes for both items (e.g., free learning, FL) might result in backward associative processes in transfer equally as potent as forward processes.

The present study compared transfer in the A-B, A-D; A-B, C-B; A-B, A-Br; and A-B, C-D paradigms as a function of ANT versus FL methods of presentation in order to (1) assess the generality of theories of transfer mechanisms to the FL method, and (2) test for the interaction of method of presentation with transfer paradigms suggested by the above analysis of associative learning processes and their interaction with method of presentation. Kanak and Neumer found that the rate of acquisition of a single eight-pair list of meaningful words did not differ between the ANT and FL methods. The FL task involved an alternating study-test trial procedure in which the S was required to recall both items of any given pair within a 4 sec. interval, a procedure which ensures the equal availability of both items in contrast to the ANT method.

The present study also used highly familiar word pairs and was designed to determine whether this equality of methods in initial acquisition extends to transfer of training phenomena. On the basis of Kanak and Neumer's findings, the strength of backward associations (B-A) is a function of the level of stimulus availability during acquisition. Thus the relative effect of B-A associations during transfer should also differ according to whether they were acquired under a method ensuring high (FL) or low (ANT) stimulus availability. Specifically, one of the major sources of negative transfer in the C-B and A-Br paradigms is the competition between old first list B-A associations and the new second list B-A associations (Martin, 1965). The increased strength of the first list B-A associations under FL should result in greater backward associative competition with an expected consequence of greater negative transfer in the C-B and A-Br paradigms under FL as opposed to ANT method learning. No differences between methods in the A-D paradigm were expected since the methods should involve equally potent forward associative competition. The degree of transfer for each paradigm within each method was evaluated relative to the A-B, C-D nonspecific transfer paradigm, a paradigm in which the two methods were not expected to lead to any differences as a function of transfer mechanisms per se.

Method

Subjects and Experimental Design. The Ss were 96 introductory psychology students at the University of Oklahoma who received course credit for their participation in the experiment. All Ss were naive with respect to verbal learning research and were randomly assigned to one of the 16 treatment groups according to a prearranged format. Furthermore, Ss were assigned to the two orders of administration for bidirectional recall in a counterbalanced fashion such that the first S assigned to a given group received order 1, the second order 2, the third order 1 etc. Those Ss who failed to reach a criterion of 6/8 correct responses on List 1 learning within 10 trials were eliminated and replaced with the next S to appear. This criterion was chosen because of evidence from a study by Kanak and Neuner (1970) that further degrees of learning on List 1 might inflate B-A recall and lead to artifactually symmetrical A-B and B-A recall for ANT groups. One S in FL C-D, one in ANT C-B, and one in FL C-B were eliminated because of failure to meet this criterion. One S in FL C-B, and one S in ANT A-Br were eliminated due to failure to understand instructions, while one S in ANT C-D was eliminated due to incorrect instructions.

Word Lists. The word materials consisted of 32 words selected from the Thorndike-Lorge (1944) word count with the principle criterion being that the words be high in frequency (all were AA) but minimally related associatively to one another as determined by the Palermo-Jenkins (1964) norms. Two 16 item subpools were created from the initial pool, one being designated the A-B list and the other the C-D list (8 St and 8 R words per list). On the basis of these two master lists, the appropriate list for each paradigm was constructed with A-B being a common second list for all four paradigms. Two sets of lists (x and y) were derived such that the St and R words of list x became the R and St words, respectively, of list y. This manipulation was included to control for the possible differential ease of forming associations in either direction on the basis of a given item's function. Thus the D terms of A-D (list x) were the D terms of C-D (list x) while the C terms of C-B (list x) were the C terms of C-D (list x). Similar relations obtained for list y C and D terms. For the A-Br list the original pairings were randomly repaired.

Procedure. Each S appeared at the laboratory at varying times throughout the day according to the time for which he signed up. Testing occurred individually. For List 1 learning, Ss were given standard ANT or FL instructions. In order to facilitate the understanding of the instructions and to provide warmup, appropriate examples of ANT or FL were given utilizing 2 pairs of low-meaningful disyllables (Noble, 1952). The Ss did not practice learning these samples but simply watched the procedure.

The lists were presented by means of a Kodak Carousel Slide Projector. For ANT groups, a 2:2 sec. rate of exposure with a 4 sec. intertrial interval (a slide with a series of 4 asterisks presented for 2 sec. followed by a slide with a single asterisk for 2 sec.) was utilized.

For FL groups, the 8 St-R pairs were presented for exposures of 2 sec. each during study trials. This was followed by a 2 sec. intertrial interval, occupied by a slide showing a single asterisk which indicated the start of the test trials. During the test trials, recall was paced by utilizing 8 blank slides presented for an exposure time of 4 sec. The S was instructed to try to give one and only one pair during each blank slide presentation. The pacing cue was thus the audible click of the projector mechanism as it dropped in a blank slide. The 8 blank slides during FL were followed by another intertrial interval (a series of 4 asterisks) of 2 sec. which indicated the end of a test trial and the beginning of a new study trial. All presentation rates were controlled mechanically by means of a pre-recorded tape which automatically programmed the slide change mechanism via a Kodak Tape Synchronizer.

Following the successful attainment of the 6/8 correct response criterion on List 1, the Ss were told that they were doing fine and that they would now learn "another list of words in exactly the same manner in which they had been learning." The Ss were also instructed that they would continue on the second list until they reached a criterion of one perfect trial or ten trials whichever came first.

Four random serial orders of presentation were utilized for the ANT method and the study portions of FL on both List 1 and List 2 in order to prevent serial learning.

Following the attainment of criterion on List 2, Ss received instructions for a paced bidirectional recall of List 1 items. Two orders of presentation were utilized in bidirectional recall with one-half of the Ss in each group receiving order 1 while the remainder received order 2. For order 1 the Ss were told that they would first see the 8 St items of List 1 followed immediately by the 8 R items of List 1. For each item the S was instructed to "give or guess" the item which was originally paired in List 1 to the item he saw on the screen. Order 2 reversed these proceedings such that the 8 R items were presented first followed by the 8 St items. All 16 items from List 1 for each group were presented at an exposure rate of 2 sec. with each item followed by a blank slide of 2 sec. which gave the S adequate time to recall.

At the termination of recall, Ss were instructed to not discuss the experiment with their classmates and were thanked for their participation.

RESULTS

List 1 Acquisition. The analysis of variance of List 1 acquisition data was based on the number of trials to the criterion of 6/8 correct responses on one trial. Differences between methods were not significant, F (1,80) = 1.44, p < .25. These results indicate a comparability of methods with respect to learning difficulty and thus replicate the findings of Kanak and Neuner (1970). Differences between groups as defined by paradigms were also nonsignificant, F (3,80) = 1.54, p < .25, and the groups may therefore be considered comparable in the degree of List 1 learning. Since the list variation was also nonsignificant, F (1,80) = < 1.00, comparable lists were combined in each condition for all further analyses. The overall mean trials to criterion was 3.90 with a standard deviation of 1.93.

List 2 Transfer. Two separate analyses of variance were performed on the List 2 transfer data. The first analysis was based on the number of correct responses on the first two trials. The second analysis was based on the total number of correct responses a S gave throughout all trials divided by the total possible number of correct responses for those trials. The criterion for List 2 was one perfect trial or ten trials whichever occurred first. Twenty-eight Ss reached the 10th trial without reaching criterion (ANT-CB, 2; ANT-AD, 2; ANT-ABr, 6; FL-CD, 2; FL-CB, 6; FL-AD, 5; FL-ABr, 5). Because of the failure of these Ss to reach criterion, the analysis of the number of correct responses to the base of opportunities was deemed a more appropriate measure than either trials to criterion or total correct responses.

Correct Responses on Trials 1-2. The FL method was a more efficient method of acquisition on the first two transfer trials than was ANT, F (1,88) = 4.24, $p < .05$. The means and standard deivations, respectively, were 6.88, 2.60 (FL) and 5.73, 3.06 (ANT). The paradigms also differed significantly from one another, F (3,88) = 3.89, $p < .025$. The means and standard deviations, respectively, were 7.54, 2.80 (CD); 6.83, 2.94 (CB); 5.75, 2.03 (AD); and 5.08, 3.17 (ABr). Dunnett's test for comparisons with a control (Winer, 1962) revealed the difference between CD and CB to be nonsignificant; between CD and AD the difference indicating negative transfer was significant ($p < .05$), and between CD and ABr the difference indicating even greater negative transfer was also significant ($p < .01$). Duncan's test for multiple comparisons (Winer, 1962), like Dunnett's, indicated the difference between CD and AD to be significant ($p < .05$), as well as the difference between CD and ABr ($p < .01$). Furthermore, the difference between CB and A-Br was also significant ($p < .05$) while no other comparisons reached a commonly accepted level of significance. The predicted interaction between methods and paradigms was not significant, F (3,88) = < 1.00.

Total Correct Responses to Base of Opportunities. The FL procedure was found, as in the previous analysis, to be a more efficient method of acquisition than was the ANT method, F (1,88) = 17.00, $p < .001$. The means and standard deviations of the proportions, respectively, were .60, .13 (ANT) and .69, .09 (FL). The paradigms also differed significantly from one another, F (3,88) = 6.00, $p < .001$. The means and standard deviations, respectively, were .70, .09 (CD); .66, .14 (CB); .64, .10 (AD); and .58, .19 (ABr). Dunnett's test revealed the difference between CD and CB to be nonsignificant as in the first analysis; between CD and AD the difference indicating negative transfer as in the first analysis was significant ($p < .05$); and between CD and ABr the difference indicating even greater negative transfer again was also significant ($p < .01$). Duncan's test on the differences between paradigms indicated significant differences between CD and AD ($p < .05$), CD and ABr ($p < .01$), results consistent with all other analyses and measures, as well as significant differences between CB and ABr ($p < .01$) and AD and ABr ($p < .05$). The predicted interaction between methods and paradigms was not significant, $F(3,88) = 2.00$, $p < .25$.

Bidirectional Recall. Two analyses of variance (2x4x2x2 with a repeated measure on the last factor for direction of recall) were performed on the bidirectional recall data. The first analysis was based on stringent scoring, i.e., the S's response was scored correct only if it was correctly paired. The second analysis was based on lenient scoring such that an appropriate response was scored correct regardless of whether it was paired correctly, but with the proviso that the response came from the correct list (first list) and correct subset of that list (i.e., either be a stimulus if a stimulus was called for or a response if a response was called for). Since the lenient analysis resulted in stantistical decisions which were virtually identical to those of the stringent analysis, only the results of the stringent analysis will be reported.

Recall was significantly better under ANT than FL, $F(1,80) = 8.52$, $p < .005$, in contrast to the direction of the method differences in the analyses of tranfer scores. The means and standard deviations, respectively, were 7.83, 4.07 (ANT) and 5.81, 3.62 (FL). These method differences could perhaps be attributed to a performance set associated with the ANT method which transfers directly to the recall task. That is the recall task resembles the ANT method procedure in that a single cue is presented for recall of the appropriate paired item. Associated with the ANT procedure is the learning of a set to alternate rapidly between storage and retrieval processes. The FL method does not require such rapid alternation during learning nor does it utilize a cue. Thus, during bidirectional recall, Ss who learned under the ANT method would appear to be at an advantage since bidirectional recall also demands rapid retrieval with the aid of a cue.

The paradigms also differed significantly relative to amounts of total recall, F (3,80) = 10.83, p < .001. The effect for order of administration (i.e., St-R, R-St and R-St, St-R) of bidirectional recall was nonsignificant, but the direction of recall effect (i.e., St-R, R-St) was significant, F (1,80) = 4.99, p < .05. The order by direction interaction was significant, F (1,80) = 8.77, p < .005. This interaction fails to have much importance, however, since order failed to interact with methods and paradigms, F (1,80) = < 1.00.

More importantly, the paradigm by direction of recall interaction was significant, F (3,80) = 8.99, p < .001. Tests of the simple effects involved in the interaction were therefore conducted. The means and standard deviations for direction of recall within each paradigm are presented in Table 1 along with the F values for comparisons between St-R and R-St orders within each paradigm. These comparisons strongly support an associative symmetry hypothesis since 1) forward and backward associative strengths do not differ in the CD control condition, and

TABLE 1

Means and Standard Deviations of the Direction of Recall X Paradigms Interaction for Bidirectional Recall With Associated *F* Values

	CD		CB		AD		ABr	
	St-R	R-St	St-R	R-St	St-R	R-St	St-R	R-St
$\bar{X}$	4.92	4.54	4.83	2.79	2.63	3.55	2.16	1.92
S.D.	(1.95)	(2.00)	(2.27)	(2.13)	(2.02)	(2.35)	(1.76)	(1.74)
$F_{(1,80)}$	<1.00		26.05**		4.79*		<1.00	

*$p < .05$

**$p < .001$

2) forward and backward associative interference both result in comparable amounts of recall decrement in the ABr paradigm. The interaction of transfer paradigms and order of recall arises in the CB and AD paradigms where amount of recall is diminished only if there is either forward or backward associative competition irrespective of the order of recall. The Newman Keuls test further delineated the nature of the interaction by paradigm comparisons for both ST-R and R-St recall. The CD-CB difference was significant only for R-St recall indicating the negative transfer associated with this paradigm is clearly due to backward associative interference. The significant difference between CD and AD for St-R but not R-St recall indicates the negative transfer for this paradigm to be a result of forward associative interference. The significant CD-ABr comparisons clearly delineated the equally potent negative transfer that results in ABr from both forward associative interference and backward associative interference. Dunnett's test for comparisons with a control confirmed all findings involving comparisons with CD at the same level of significance found with the Newman Keuls test ($ps < .01$). Further comparisons, as expected, indicated a significant difference between AD and CB with CB showing greater ST-R recall than AD (due to forward associative interference in AD) and less R-St recall than AD (due to backward associative interference in CB. This latter difference did not reach a commonly accepted level of significance, however. Comparisons between AD and ABr indicated no difference for ST-R recall (due to comparable forward associative interference in both paradigms) but superior R-St recall for AD (due to the absence of backward associative

interference in AD). The last paradigm comparison, that between CB and ABr, indicated St-R recall for CB to be significantly superior to AD (due to the forward associative interference in AD) while R-St recall was comparable (due to the equal effects of backward associative interference in each paradigm). All significant differences for paradigm comparisons = $\underline{p} < .01$.

The methods by paradigm by direction interaction was nonsignificant, $\underline{F}$ (3,80) = 1.58, $\underline{p} < .25$, and is thus consistent with the lack of a method by paradigms interaction during transfer.

Discussion

The paradigm effects of the present study are highly consistent with the previous transfer literature. Relative to the CD control condition, the CB condition resulted in essentially zero transfer, a result expected under conditions of high meaningful response terms (Jung, 1963). Similarly, the ABr condition resulted in rather massive negative transfer, a result consistent with other studies utilizing high meaningful response items (eg. Merikle and Battig, 1963). The AD paradigm yielded an intermediate but significant amount of negative transfer consistent with other findings employing high meaningful materials (eg. Jung, 1963; Merikle and Battig, 1963).

The lack of a Paradigm by Method interaction, on the surface, suggests considerable generality across methods for the transfer theories and empirical results generated by research with the anticipation method. There remains the possibility, however, that the present criterion for List 1 learning of 6/8 correct responses may not have produced a sufficient number of associatively learned pairs to detect the predicted Paradigm by Method interaction. It is conceivable that the 6/8 criterion for associative learning may have produced an amount of associative learning sufficiently within the immediate memory span that Ss could have inhibited some degree of associative competition. Since the free learning method separates storage and retrieval process and demands no rapid alternation between these two process as in the anticipation method, the free learning method would appear to enhance the ability to inhibit competing associations which are within the immediate memory span. Thus, the increased amount of backward associative competition in the CB and ABr paradigms expected under the free learning method, relative to the anticipation method, may have been substantially reduced due to such inhibition, the overall result being a failure to obtain the predicted Paradigms by Method interaction.

The 6/8 criterion was chosen on the basis of evidence presented by Kanak and Neuner (1970) that this degree of learning resulted in significant asymmetry under the anticipation method while a perfect-trial criterion produced statistically marginal asymmetry. The 6/8 criterion in the present research resulted in a level of recall of approximately 57% ($\bar{X}$ = 9.04 of 16), although this value undoubtedly represents some degree of unlearning arising from the interlist competition between contextual associations (Houston, 1967; Kanak and Curtis, 1970; McGovern, 1964). To evaluate the degree of associative learning presumably present before the introduction of List 2 learning, a post hoc free learning group of 16 Ss learned List 1 of the CD paradigm, followed immediately by bidirectional recall. The recall data indicated not only symmetrical St-R and R-St learning, but the overall level of associative learning was approximately only 71% (St-R: $\bar{X}$ = 6.0; R-St: $\bar{X}$ = 5.66). Further research employing a higher criterion of List 1 learning and/or a longer list would therefore seem desirable before the paradigm equivalence effects of the two methods could be readily accepted.

The results of the bidirectional recall tasks, particularly the Paradigm by Direction of Recall interaction, presented impressive evidence in support of the associative mechanisms assumed to be involved in the transfer paradigms. The CD condition, lacking specific associative competition mechanisms, resulted in symmetrical recall. In contrast the ABr paradigm, involving bidirectional associative competition, also resulted in symmetrical recall but to a degree significantly less in both directions than in the CD condition.

Forward associative (i.e. St-R) recall in the A-D paradigm was significantly less than R-St recall and also less than St-R recall in the C-D paradigm, as expected, due to the involvement of forward associative competition in the AD condition. Conversely, R-St recall in the CB paradigm was inferior to St-R recall and also inferior to R-St recall in the CD paradigm, as predicted, due to the involvement of backward associative competition. The second-order interaction of Paradigm by Method by Direction of Recall was nonsignificant, a result consistent with the lack of a predicted Paradigm by Method interaction in the transfer measures.

A theoretically challenging question is posed by the presence of method differences in List 2 transfer, with the free learning method resulting in significantly less negative transfer than the anticipation condition, as contrasted with the absence of such differences in List 1, a result consistent with the evidence presented by Kanak & Neuner (1970) for single-list learning. This results implies an interaction between methods in the learning of non-interfering versus interfering materials. It is conceivable that the higher degree of stimulus-item learning accomplished in the FL method could result in an ability to more easily differentiate between List 1 and List 2 associations with resultant increased ease in inhibiting competing associations. Alternatively, the rapid alternation between storage and retrieval processes associated with the anticipation method could interact with the presence of associative competition to produce increased difficulty, relative to the separation of storage and retrieval processes in the study-test procedure of the free learning method. Systematic study of the obtained phenomena seems warranted due to the rather pronounced method effects obtained in the transfer measures.

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APPENDICES

APPENDIX A

PROSPECTUS

Virtually every study of transfer of training in verbal learning has used the anticipation method. Little is known of the generality of transfer theories or theories of transfer mechanisms beyond the anticipation method. Whether such theories and the usual transfer results would hold up under alternative methods of presentation is open to question.

In the typical anticipation method of paried-associate (PA) learning, the subject (_S_) is required to associate a specific stimulus (St) and response (R) term with one another. During the anticipation interval the St is presented alone followed immediately by a simultaneous presentation of the St and R. The latter presentation serves as an informative feedback interval. Following the first learning trial the _S_ tries to anticipate (usually orally) the correct R when the St is presented. In order to receive credit the _S_ must anticipate the R before the presentation of the St and R in the feedback interval. The rate of exposure for the anticipation and feedback intervals are usually equated, eg. a 2:2 sec. rate of exposure. To prevent serial learning of the list of pairs, a number of different random orders are usually employed so that the order of pairs is different from trial to trial.

Paired-associate learning has been conceptualized as consisting of two stages (Underwood, Runquist, and Schulz, 1959; Underwood and Schulz, 1960), a response learning stage and an associative learning stage.

During the response learning stage, response differentiation and integration occur, whereas in the associate stage, the response terms are "hooked-up" with their appropriate stimulus members. The factor of stimulus learning and stimulus differentiation did not receive much attention in their analysis though others (eg. McGuire, 1961) consider it as a component in PA learning.

The lack of attention paid to the stimulus in PA learning may, in part, be attributable to the unequal requirements inherent in the anticipation method with respect to S's task regarding the St and R terms. For while the R must be available to the S so that he can produce it, the St must only be recognized. The fact that the St need only be recognized allows the S under some circumstances (eg. low meaningfulness) to use only a component of the St term (functional stimulus) as a cue in effectively associating the R term with the St term rather than utilizing the whole or nominal stimulus (Underwood, Ham and Ekstrand, 1962). Such fractionizing cannot of course occur with the R terms since they must be given in their entirety during recall.

The lack of attention paid to the stimulus in PA learning seems justified on the basis of studies like those of Underwood and Schulz (1960) and Hunt (1959) who found that variables which affect learning, such as meaningfulness (M), are more powerful on the R terms than on the St terms. Such results are easy to understand since both studies used the anticipation method with its unequal recall requirements. However, studies which avoid these unequal recall requirements disagree with the above conclusions. Epstein and Streib (1962) made use of a recognition test so that no response learning was necessary. When presented with a St, the S could chose one of three R alternatives. The St-R pairs were formed with paralogs comprising low-high or high-low M lists. They predicted that the list with high M responses would be better learned under the anticipation method, but that the use of their recognition test method would lead to equal learning of the two lists. The results supported the predictions except when the similarity of the recognition alternatives was high. Even more relevant to the Underwood and Schulz (1960) and Hunt (1959) conclusions is a study by Epstein and Platt (1964). In order to avoid the mixing of recognition and recall processes inherent in the anticipation method, they utilized a free-recall method in a study of the effect of variations in M of both St and R in PA learning. Free-recall (variously termed free-learning, study-test, free-recall learning) is a method whereby all items to be learned are presented successively during a study trial followed by a recall period in which no cues for recall are given. The Ss are usually free to recall the items in any order they chose. The recall may be either paced or unpaced. The unpaced variety has been criticized as allowing the S additional time in which he may be learning. By utilizing the free-recall method, Epstein and Platt insured the equal availability of both the St and R items since both items must be produced rather than just the R item as in the anticipation method. Their finding was that variations in St rather than R meaningfulness had a greater effect on performance.

The unequal availability of St and R items in the anticipation method has become a focal point of controversy regarding the strength of backward as opposed to forward associations. When a S learns an association between a St and a R, it has long been known that he not only can give the R when the St is presented (forward association) but that he can also give the St when presented with the R (backward association). Usually, however, forward associations have been found to be stronger than backward associations (Ekstrand, 1966). Backward associations can be considered a form of incidental learning, since no instructions are provided to the Ss that they are supposed to learn or will be tested on backward associations. Jantz and Underwood (1958) demonstrated that both types of associative learning improve as a direct function of the number of practice trials on forward associative learning, although forward learning reached a higher level than backward and the R-St curve indicated an asymptote considerably lower than that of the St-R curve. These findings led them to the conclusion that backward learning is a form of incidental learning.

This position has been challenged by the associative symmetry model of Asch and Ebenholtz (1962) who hold that "when an association is formed between two distinct terms, a and b, it is established simultaneously between b and a." They further maintain that there are no conditions in which an A-B association is formed without producing an association of equal strength between B-A.

The interpretation offered by Asch and Ebenholtz for the frequent findings of greater St-R learning than R-St learning is that there exists an unequal availability of St and R terms and that the differences between measured strength of forward and backward associations are primarily an artifact produced by measurement procedures. In order to validly compare the strengths of forward and backward learning, the conditions of recall, or item availability, must be equated. In the typical anticipation procedure such a condition does not obtain. Therefore, the typical finding of weaker R-St recall might be a function of weaker availability of St terms following recognition learning.

Support for the associative symmetry position has come from many quarters (eg. Wohlgemuth, 1913; Guthrie, 1933; Hermans, 1935; Murdock, 1956; Horowitz, Brown, and Weisbluth, 1964; Horowitz, Norman, and Day, 1966; Houston, 1964; Leicht and Kausler, 1965). Presently, no conclusive evidence exists for or against the associative symmetry model of Asch and Ebenholtz, for even when studies have met the condition of equal availability of St and R terms, the results have either been conflicting or open to criticism on methodological grounds (Ekstrand, 1966). As Ekstrand has suggested, learning may indeed be symmetrical but the existing performance measures favor asymmetry. There is one study, however, which has systematically attempted to compare various methods of presentation in testing the associative symmetry model (Kanak and Neuner, 1970). Kanak and Neuner investigated the symmetry of associative recall following five methods of PA acquisition which differed in the type of learning process each involved for either the St or R, or both. Three methods required differential learning processes for the St and R. These were the standard anticipation method, and two variants of the study-test procedure (Battig and Brackett, 1961). The first study-test variant (ST-B) required recall of R items in response to St items while the other variant (ST-A) conversely involved recall of St items in response to presented R items. Two other methods, ST-AB and recognition (REC), involved non-differential learning processes during acquisition for both St and R items and were thus expected to yield symmetrical recall as opposed to the three former, differential, learning processes. The ST-AB method was conducted in a ST procedure, but the S̲ was required to recall both items of each pair on test trials. The

REC method required the S to select and verbalize both components of the (correct) experimental pair which was presented contiguously with two extralist buffer pairs in a modified anticipation procedure. The exposure of each set of three such pairs was followed by a feedback interval in which the three pairs reappeared in the same order, but with the items of the correct pair under-scored. Following acquisition for all groups a paced bidirectional recall task was utilized.

Kanak and Neumer found asymetricial recall in the three conditions involving differential learning processes, while the two nondifferential methods resulted in symmetrical recall. These results represent support for the major tenets of Asch and Ebenholtz (1962). It is important to note that the predictions were supported for all except the anticipation group, though the latter difference between St-R and R-St was in the expected and usual direction. Furthermore, an extra anticipation group was run (post hoc) to explore this atypical finding. The criterion for learning was reduced from the criterion used in the main experiment (from one perfect trial to 6/8 correct on one trial) to study the possibility that some degree of overlearning may have inflated the R-St recall. This extra anticipation group showed the typical asymmetrical recall. However, it is impossible to ascertain whether the symmetrical recall of the anticipation group in the main experiment was a function of overlearning or a more general Type 2 error.

From the foregoing it thus appears that many of the theories and results in verbal learning need re-examination in the light of the specialized nature of the anticipation method, a method which inherently assigns a more important role to the R than to the St. The major focus of the present study is an attempt to study the effect of variations in St availability as a function of method of presentation (ie. anticipation vs. free-recall) in the area of transfer of training.

Transfer is a gross learning phenomenon that represents the effects of past learning on present acquisition. Transfer may be positive or negative in direction and may vary in degree according to the transfer paradigm and its interaction with secondary variables. Transfer may be subdivided between specific and nonspecific sources. Nonspecific transfer is composed of two subcomponents, warmup and learning-to-learn (eg. Thune, 1951). Specific transfer is above and beyond that found with a nonspecific control condition and represents the effects of the interlist St and/or R similarity. The major subcomponents of specific transfer are considered to be 1) response learning (RL), 2) forward associations (F), and 3) backward associations (B), (Martin, 1965). These three mechanisms seem well established. The additional mechanism of stimulus discrimination has remained largely neglected in the transfer literature, though logic would entail its presence (eg. McGuire, 1961). Regarding stimulus discrimination, for instance, Underwood and Ekstrand (1968) and Saravo and Price (1967) have noted that stimulus discrimination is a source of only very slight positive transfer. Its effects are presumably masked by the more potent sources of transfer in most studies.

Basic Transfer Paradigms and Hypotheses

A-B - C-D

The C-D paradigm is the nonspecific control paradigm against which the transfer effects of the other paradigms may be measured. The St and R terms of both lists are unrelated. The utilization of a free-learning vs anticipation method would not be expected to lead to any differences in this paradigm as a function of transfer mechanisms per se. However, the two methods might be demonstrated to be not equally efficient.

A-B - A-D

The A-D paradigm is the classical negative transfer paradigm with the St terms of both lists being identical and the R terms unrelated. The potent negative transfer is a result of response competition in second list acquisition. The forward association A-B interferes with acquisition of the A-D association (Martin, 1965). A weak positive source of transfer is stimulus differentiation (Gibson, 1940; Underwood and Ekstrand, 1968; Saravoy and Price, 1967). No differences between the free-learning and anticipation methods would be expected in this paradigm since forward associative interference should be equally potent in both methods.

A-B - C-B

The C-B paradigm involves unrelated St terms while the R terms are identical. The negative transfer component in this paradigm is due to the backward associations of each list interfering with each other (B-A and B-C). Response learning is transfered from first to second list, and since the responses are the same in each list, this is a positive source of transfer relative to the A-B, C-D control condition. However, since the usual finding with C-B paradigms is some degree of negative transfer, the above associative component would appear to be more potent. The level of M of the R terms also contributes to the magnitude and direction of transfer in the C-B paradigm. As Martin (1965) has noted, when high-M responses are used, the extensive response-learning phase is not necessary, allowing more emphasis on the formation of the backward associations which will cause interference in the subsequent transfer task. An increase in response M means an increased opportunity for the development of negative backward effects, thus either a decrease in positive transfer or an increase in negative transfer, depending on the given degree of List I learning. Empirical confirmation of these theories relating response M to the direction and amount of transfer in the C-B paradigm has been provided by Jung (1963).

The anticipation method, as opposed to free-learning, should lead to less negative transfer in the C-B paradigm. This prediction is based on Kanak and Neuner's (1970) findings that free-learning leads to an increased potency of the first list backward association B-A. This increased potency of B-A would lead to increased interference between it and the second list backward association B-C. This increased negative transfer under free-learning may perhaps be as great as the negative transfer found in the free-learning A-D paradigm. This possibility could arise since there are the same number of interfering associations in each paradigm with an assumed equal strength, be they forward or backward associations.

A-B - A-Br

The A-Br paradigm has the same set of St and R terms in both lists but with totally new associations between a given St and R. Thus it is spoken of as a re-paired paradigm (Porter and Duncan, 1953). The A-Br paradigm involves a positive response learning effect, potent negative forward and backward associative competition effects and an additional negative forward associative competition effect (Martin, 1965). The additional forward associative interference arises because the presence of first-task responses tends to elicit backwardly the interfering forward associations acquired in the first task, thus causing these associations to be more resistant to extinction. The A-Br paradigm therefore usually leads to massive negative transfer.

Free-learning may be expected to yield greater negative transfer than the anticipation method in the A-Br paradigm since the backward association B-A should be more potent as a result of stronger learning of A items. Nonetheless, negative transfer should be greater than that in A-D for both methods because of three modes of interference.

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APPENDIX B

Master Word Lists

A		B	C		D
BUTTER	-	HAPPY	DAILY	-	WOOD
DARK	-	FAST	CITY	-	HIGH
COLD	-	OVER	INCH	-	BIRD
TABLE	-	SOLDIER	SOFT	-	AFRAID
QUEEN	-	WHITE	WINDOW	-	HEAD
SHOES	-	OCEAN	EARTH	-	DOCTOR
DREAM	-	NARROW	FRUIT	-	RIGHT
SQUARE	-	CLOSER	LAMP	-	PLAY

APPENDIX C

Instructions for the Anticipation Groups

Your task in this experiment is to learn pairs of words. I have some made up examples to show you which will help you to understand the procedure. This first slide, "GOJEY", is the stimulus which will remain on the screen for two seconds. Now you will notice on this next slide "GOJEY" is paired with "NEGLAN", this pair also appears for two seconds, "GOJEY" being the stimulus and "NEGLAN" the response. Now here is another made up pair. The first slide, the stimulus, is shown for two seconds, and then the stimulus-response pair for two seconds. After what will be six other pairs you see a slide with four asterisks on it. This slide indicates that the list of eight pairs is over. Then you will see another slide with a single asterisk which indicates that the list is about to begin again. Now you see "GOJEY", and if you can remember what "GOJEY" was paired with last time, you would want to say it now. In the learning task we are about to begin you would want to say "NEGLAN" before the slide with "GOJEY-NEGLAN" appears. The idea is thus to anticipate the response. Do you have any questions?

Instructions for the Free-Learning Groups

Your task in this experiment is to learn pairs of words. I have some made up examples to show you which will help you to understand the procedure. This first slide, "GOJEY-NEGLAN", will remain on the screen for two seconds. "GOJEY" is the stimulus, and "NEGLAN" is the response. You would study this pair and try to remember it during a later test period. Here is another slide showing a stimulus-response example. This pair also appears for two seconds. In the experiment you will see eight such pairs, each presented successively for two seconds. At the end of the list of eight pairs you will see a slide with a single asterisk which indicates that the test period is about to begin. Then there will follow eight blank slides during the test period. As you will notice, you do not see anything, but you can hear the click when the slide drops into the projector. There is one blank slide for every stimulus-response pair that you will be learning. Each blank slide will remain for an interval of four seconds during which time you would want to give, out loud, one stimulus-response pair. You may give only one pair during a single blank slide, and you must wait to give additional pairs until another blank slide drops in. Following the eight blank slides you will see a slide with four asterisks. This will indicate that the study period is about to begin again. Now you see "GOJEY-NEGLAN" which will be followed by the seven other pairs. In the learning task we are about to begin you would want to study all of the pairs and then recall as many as possible in each study period. Do you have any questions?

Paced Bidirectional Recall

Order 1

The last task that I am going to have you perform does not involve the learning of any new words. All of these words come from the very first list that you learned. You will see each stimulus word on the screen for a two second exposure. Each stimulus word will be followed by a blank slide for two seconds which will give you time to give the response which goes with each stimulus. Immediately following the eight stimuli will be the eight response words of list 1. For each response word I would like you to give the stimulus which goes with it. You will go through this list just one time. You may guess at the answers if you are not sure. Remember all of these words are from the very first list. Do you have any questions?

Paced Bidirectional Recall

Order 2

The last task that I am going to have you perform does not involve the learning of any new words. All of these words come from the very <u>first</u> list that you learned. You will see each response word on the screen for a two second exposure. Each response word will be followed by a blank slide for two seconds which will give you time to give the stimulus which goes with each response. Immediately following the eight responses will be the eight stimulus words of list 1. For each stimulus I would like you to give the response which goes with it. You will go through this list just one time. You may guess at the answers if you are not sure. Remember all of these words are from the very first list. Do you have any questions?

APPENDIX D

List 1 Raw Data

Trials to Criterion

Ant C-D (x)	Ant C-D (y)	FL C-D (x)	FL C-D (y)
6	3	5	3
4	2	4	5
4	2	2	4
5	5	5	4
2	7	5	7
6	6	2	2

Ant C-B (x)	Ant C-B (y)	FL C-B (x)	FL C-B (y)
2	5	4	7
2	7	10	5
3	5	4	3
2	1	4	8
2	8	2	3
2	3	5	5

Ant A-D (x)	Ant A-D (y)	FL A-D (x)	FL A-D (y)
1	4	3	2
5	5	9	2
5	5	2	3
6	4	4	2
3	3	4	2
3	3	6	9

Ant A-Br (x)	Ant A-Br (y)	FL A-Br (x)	FL A-Br (y)
3	5	5	2
2	6	3	2
2	2	4	3
2	1	6	3
1	3	2	3
4	4	6	3

List 2 Raw Data

Number Correct On First Two Trials

Ant C-D	FL C-D	Ant A-D	FL A-D
8	6	4	7
4	12	5	10
9	7	5	6
8	4	6	6
7	8	3	6
8	10	4	9
4	7	4	6
1	10	3	3
11	13	6	4
8	10	4	9
6	5	5	9
9	6	7	7

Ant C-B	FL C-B	Ant A-Br	FL A-Br
10	6	8	2
8	5	9	7
4	5	12	10
5	6	3	4
8	8	3	8
1	11	3	8
7	2	2	2
9	10	3	6
8	6	5	6
3	7	0	3
14	5	1	5
7	9	3	9

List 2 Raw Data

Total Correct to Base of Opportunities

Ant C-D	FL C-D	Ant A-D	FL A-D
.59	.75	.56	.73
.64	.73	.57	.75
.73	.83	.45	.82
.52	.80	.65	.61
.50	.75	.58	.71
.75	.81	.70	.59
.71	.75	.59	.74
.69	.70	.41	.68
.66	.67	.65	.65
.72	.75	.70	.72
.76	.56	.51	.68
.71	.80	.63	.66

Ant C-B	FL C-B	Ant A-Br	FL A-Br
.75	.69	.65	.40
.73	.38	.55	.54
.75	.66	.63	.66
.69	.83	.51	.63
.50	.65	.68	.78
.77	.63	.44	.69
.69	.64	.46	.69
.58	.70	.49	.63
.69	.65	.55	.75
.88	.61	.32	.60
.26	.80	.41	.66
.56	.78	.50	.72

Bidirectional Recall Raw Data

Condition	Stringent Scoring	Lenient Scoring
A1-B1-C1-D1	= 8, 1, 1, 5, 6, 8	8, 1, 1, 5, 6, 8
A1-B1-C1-D2	= 8, 3, 1, 8, 7, 8	8, 3, 1, 8, 7, 8
A1-B1-C2-D1	= 6, 3, 6, 4, 7, 5	6, 3, 6, 4, 7, 5
A1-B1-C2-D2	= 4, 5, 7, 3, 3, 4	4, 5, 7, 3, 3, 4
A1-B2-C1-D1	= 8, 8, 8, 4, 2, 4	8, 8, 8, 4, 2, 5
A1-B2-C1-D2	= 2, 6, 8, 3, 1, 4	2, 6, 8, 3, 1, 4
A1-B2-C2-D1	= 7, 6, 6, 4, 4, 7	7, 6, 6, 4, 4, 7
A1-B2-C2-D2	= 1, 2, 4, 0, 4, 2	1, 2, 4, 0, 4, 2
A1-B3-C1-D1	= 1, 3, 6, 1, 2, 1	1, 3, 6, 1, 2, 1
A1-B3-C1-D2	= 7, 3, 8, 4, 6, 5	7, 3, 8, 4, 6, 5
A1-B3-C2-D1	= 4, 3, 7, 6, 3, 4	4, 3, 7, 6, 3, 4
A1-B3-C2-D2	= 3, 1, 4, 4, 5, 4	3, 1, 5, 5, 5, 4
A1-B4-C1-D1	= 3, 3, 4, 5, 3, 3	3, 3, 5, 5, 3, 3
A1-B4-C1-D2	= 0, 5, 6, 4, 2, 1	0, 5, 6, 5, 2, 3
A1-B4-C2-D1	= 1, 2, 3, 0, 0, 5	2, 4, 3, 6, 0, 5
A1-B4-C2-D2	= 1, 0, 0, 0, 0, 4	1, 4, 0, 0, 0, 5
A2-B1-C1-D1	= 4, 6, 5, 2, 5, 5	4, 6, 5, 2, 5, 5
A2-B1-C1-D2	= 3, 5, 3, 3, 6, 4	3, 5, 3, 3, 6, 4
A2-B1-C2-D1	= 5, 7, 6, 6, 2, 5	6, 7, 6, 6, 2, 5
A2-B1-C2-D2	= 6, 2, 5, 5, 3, 3	6, 2, 5, 5, 3, 3
A2-B2-C1-D1	= 7, 8, 3, 0, 3, 4	7, 8, 4, 0, 3, 6
A2-B2-C1-D2	= 5, 4, 2, 6, 0, 3	6, 4, 3, 6, 0, 4
A2-B2-C2-D1	= 6, 5, 2, 3, 2, 5	6, 5, 2, 4, 3, 5
A2-B2-C2-D2	= 2, 0, 0, 4, 1, 3	2, 0, 0, 4, 1, 3
A2-B3-C1-D1	= 2, 2, 0, 0, 2, 3	3, 2, 0, 0, 2, 3
A2-B3-C1-D2	= 0, 4, 1, 0, 3, 6	0, 4, 1, 0, 5, 6
A2-B3-C2-D1	= 1, 0, 0, 4, 5, 3	1, 0, 0, 4, 6, 3
A2-B3-C2-D2	= 0, 0, 1, 4, 6, 5	0, 0, 1, 4, 6, 7
A2-B4-C1-D1	= 0, 1, 6, 0, 3, 3	7, 2, 6, 0, 6, 3
A2-B4-C1-D2	= 2, 2, 4, 1, 1, 1	3, 2, 4, 4, 1, 1
A2-B4-C2-D1	= 2, 2, 1, 0, 2, 0	7, 3, 1, 3, 3, 2
A2-B4-C2-D2	= 1, 4, 3, 1, 2, 1	2, 4, 3, 2, 2, 1

A1 = Anticipation; A2 = Free Learning
B1 = CD; B2 = CB; B3 = AB; B4 = ABr
C1 = Order 1 (St-R, R-St); C2 = Order 2 (R-St, St-R)
D1 = Direction 1 (St-R); D2 = Direction 2 (R-St)

Raw Data Post Hoc

	Order 1	Order 2
St-R	8, 5, 5, 6, 6, 8	3, 8, 6, 6, 6, 5
R-St	8, 3, 6, 4, 7, 8	5, 7, 4, 5, 6, 5

APPENDIX E

Analyses of Variance

Summary of the 2X2X4 Analysis of Variance

for Trials to Criterion for List 1

Source	SS	df	MS	F	P
Method (A)	5.04	1	5.04	1.44	<.250
List (B)	0.67	1	0.67	<1.00	
Paradigm (C)	16.21	3	5.40	1.54	<.250
A X B	13.51	1	13.51	3.86	<.100
A X C	11.20	3	3.73	1.07	>.250
B X C	15.23	3	5.08	1.45	<.250
A X B X C	10.77	3	3.59	1.03	>.250
Error	280.33	80	3.50		

Summary of the 2X4 Analysis of Variance

of Number Correct on First Two Trials

of List 2

Source	SS	df	MS	F	P
Method (A)	31.51	1	31.51	4.24	<.05
Paradigm (B)	86.62	3	28.87	3.89	<.025
A X B	20.17	3	6.72	<1.00	
Error	653.94	88	7.43		

Summary of the 2X4 Analysis of Variance
of Total Correct to the Base
of Opportunities for List 2

Source	SS	df	MS	F	P
Method (A)	.17	1	.17	17	<.001
Paradigm (B)	.18	3	.06	6	<.025
A X B	.06	3	.02	2	<.250
Error	.94	88	.01		

Summary of the 2X4X2X2 Analysis of Variance

With a Repeated Measure on the Last Factor

For Bidirectional Recall with

Stringent Scoring

Source	SS	df	MS	F	P
Method (A)	49.0052	1	49.0052	8.5180	<.005
Paradigm (B)	186.9739	3	62.3246	10.8331	<.001
Order (C)	11.5052	1	11.5052	1.9998	<.25
A X B	12.3906	3	4.1302	<1.00	
A X C	5.6718	1	5.6718	<1.00	
B X C	17.0572	3	5.6857	<1,00	
A X B X C	4.1406	3	1.3802	<1.00	

Summary of the 2X4X2X2 Analysis of Variance
With a Repeated Measure on the Last Factor
For Bidirectional Recall with
Lenient Scoring

Source	SS	df	MS	F	*p*
Method (A)	28.5208	1	28.5208	4.6359	<.05
Paradigm (B)	89.5416	3	29.8472	4.8515	<.005
Order (C)	8.3333	1	8.3333	1.3545	<.25
A X B	15.6041	3	5.2013	<1.00	
A X C	1.6875	1	1.6875	<1.00	
B X C	17.2916	3	5.7638	<1.00	
A X B X C	2.8541	3	0.9513	<1.00	
Error	492.1666	80	6.1520		
<u>Repeated Factors</u>					
Direction (D)	20.0208	1	20.0208	8.3347	<.01
A X D	0.3333	1	0.3333	<1.00	
B X D	64.4375	3	21.4791	8.9418	<.001
C X D	22.6875	1	22.6875	9.4449	<.001
A X B X D	6.3749	3	2.1249	<1.00	
B X C X D	4.5208	3	1.5069	<1.00	
A X C X D	8.3333	1	8.3333	3.4692	<.10
A X B X C X D	5.1250	3	1.7083	<1.00	
Error	192.1666	80	2.4020		

Summary of the Simple Effects Analysis of Variance

of the BXD Interaction for Bidirectional Recall

Source	SS	df	MS	F	P
B at D_1 (St-R)	150.13	3	50.04	13.03	<.001
B at D_2 (R-St)	88.86	3	29.62	7.71	<.001
Error (within cell)	614.50	160	3.84		
D at B_1 (C-D)	1.69	1	1.69	<1.00	
D at B_2 (C-B)	50.02	1	50.02	26.05	<.001
D at B_3 (A-D)	9.19	1	9.19	4.79	<.05
D at B_4 (A-B_r)	0.75	1	0.75	<1.00	
$Error_w$	154.25	80	1.92		

Summary of the 2X2 Analysis of Variance with a Repeated Measure on the Last Factor for Bidirectional Recall (Post Hoc FL)

Source	SS	df	MS	F	P
A (Order)	2.66	1	2.66	3.06	<.25
Error					
Repeated Measures					
B (Direction)	0.66	1	<1.00		
A X B	0.01	1	<1.00		
Error	41.33	10	4.13		

APPENDIX F

Means and Standard Deviations

Method Variants-List 2

Proportions for Total Correct to Base of Opportunity

	Anticipation	Free Learning
$\bar{X}$	.60	.69
S.D.	.13	.09

Number Correct on First Two Trials

	Anticipation	Free Learning
$\bar{X}$	5.73	6.88
S.D.	3.06	2.60

Paradigm Variants-List 2

Proportions for Total Correct to Base of Opportunity

	CD	CB	AD	ABr
$\bar{X}$	.70	.66	.64	.58
S.D.	.09	.14	.10	.19

Number Correct on First Two Trials

	CD	CB	AD	ABr
$\bar{X}$	7.54	6.83	5.75	5.08
S.D.	2.80	2.94	2.03	3.17

Method Variants-Bidirectional Recall

Stringent Scoring

	Anticipation	Free Learning
$\bar{X}$	7.83	5.81
S.D.	4.07	3.62

Lenient Scoring

	Anticipation	Free Learning
$\bar{X}$	8.27	6.73
S.D.	3.81	3.50

Paradigm Variants-Bidirectional Recall

Stringent Scoring

	CD	CB	AD	ABr
$\bar{X}$	9.04	7.63	6.13	4.08
S.D.	3.49	3.55	3.80	3.08

Lenient Scoring

	CD	CB	AD	ABr
$\bar{X}$	9.50	8.00	6.46	6.04
S.D.	3.51	3.54	3.98	2.94

Means and Standard Deviations

for the B X D Interaction

		S-R	R-S
C-D	$\bar{X}$	4.92	4.54
	S.D.	1.95	2.00
C-B	$\bar{X}$	4.83	2.79
	S.D.	2.27	2.13
A-D	$\bar{X}$	2.63	3.55
	S.D.	2.02	2.35
A-Br	$\bar{X}$	2.16	1.92
	S.D.	1.76	1.74