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Transfer of Serial Position Effect to Paired-Associate Learning

James Lloyd Beckles
Eastern Illinois University

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TRANSFER OF SERIAL POSITION EFFECT TO PAIRED-ASSOCIATE LEARNING

(TITLE)

BY

JAMES LLOYD BECKLES

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

MASTER OF ARTS IN EXPERIMENTAL PSYCHOLOGY

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1977
YEAR

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TRANSFER OF SERIAL POSITION EFFECT

TO PAIRED-ASSOCIATE LEARNING

BY

JAMES LLOYD BECKLES

B. A. in Psychology, Rutgers University, 1976

ABSTRACT OF A THESIS

Submitted in partial fulfillment of the requirements
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ABSTRACT

The experiment was designed to evaluate the role of position in serial learning. In the position learning task, subjects learned two serial lists presented alternately, then learned a subsequent paired associate list consisting of items of the previously learned serial list. The paired associate list contained three types of pairs; the same position-same pair, different position-same pair, and different position-different pair. The findings of the experiment supported the position hypothesis that if position is the cue for the recall of the item in a serial list, then, a subsequent paired associate list that is made up of the two previously learned serial lists will produce maximum positive transfer for the same position-same pair items. For the pairs that were constructed so that items occupying the same ordinal position in the serial lists were paired but were moved to a new position in the paired associate list, i.e., different position-same pair, the percentage of correct response was significantly less than the same position-same pair items and significantly greater than different position-different pair items; F=222.18, df=2. The latter pairs were constructed of syllables from the serial lists but were in a new ordinal position and were paired with a syllable that had a different ordinal position. The Tukey multiple comparison test for the differences between the three types of items was significant at α=.01; CR=1016.59. Furthermore, the linear trend in the data was striking and yielded an orthogonal contrast that was highly

significant; F=443.83. The quadratic function was not significant, F=.53. The findings contradict both the remote association and sequential hypothesis in serial learning. The highly significant F for the different levels of position was F=222.1826, df=2 is reflected in Ω^2=.34, which indicated that 34% of variation is accounted for by the different levels of position. The results provided evidence that it is not only same position items that caused positive transfer from serial lists to a paired associate list, but also the same paired items that are in a new ordinal position.

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EXAMINING THE POSITION HYPOTHESIS IN SERIAL LEARNING

Ebbinghaus (1885) developed an appealing view of the serial learning that each item in a list comes to serve as the stimulus for the next item, forming a chain of direct, adjacent associations. He further established the idea of remote associations. The idea of remote association affirms that during serial learning, associative bonds are also formed between items which are non-adjacent, or remote from each other in the list and these associations are weaker than adjacent associations.

Analytic and experimental developments of three psychologists, Lashley, Ebenholtz and Young, seriously challenged the traditional view which is, adjacent and remote association, and forced reconsideration of the entire process of serial learning.

Lashley (1951) wrote a paper entitled, "The Problem of Serial Order in Behavior". This paper stands as one of the earliest influential analysis of the problem. He rejected an associationistic explanation and tentatively concluded that a serial performance, once mastered, has the properties of an integrated whole, rather than being a collection of independent responses.

Young's work (1962) was one of the first direct tests of the traditional associationistic interpretation of serial learning. In his experimental approach, Young found that the stimulus for a serial item was neither the preceeding item nor a cluster of preceeding items, but that it might have something to do with the

position of the item in the list. Young designed a series of experiments to identify the effective stimulus in serial verbal learning. Three hypotheses regarding the effective stimulus in serial learning were tested in this study. First, Young tested the specificity hypothesis by measuring transfer from a serial list to a subsequent paired associate (PA) list composed of pairs chosen from adjacent items in the serial list. If associations are formed between adjacent items in serial learning, positive transfer should obtain from the serial to the PA list. Positive transfer was observed only early in the list learning. The second alternative, called the compound stimulus hypothesis, was tested in Young's second experiment by measuring transfer from a serial to a paired associate list, composed of items taken from the serial list but where non-adjacent items were paired. If the effective stimulus in serial learning is the two preceeding items in the list, then when sets of two items are used as stimuli, positive transfer should be observed in a subsequent PA task. Young found that negative transfer occured.

The hypothesis was tested in his third experiment by observing transfer from one serial list to a second composed of the same items as the first. If the position of the item in the serial list is the effective stimulus, positive transfer should obtain from one serial list to another when the items retain the same serial position, and negative transfer obtained when the serial position is changed. It was found that items retaining the same serial position were learned faster than items which had their serial positions changed from one

list to another.

Horowitz and Izawa (1963) investigated transfer from serial to paired associate learning as a function of associative relationships among the items employed in the list. In their experiment the arrangement of items in the serial list was identical to the arrangement of the same item in the subsequent PA list. Varying amounts of transfer were obtained in the various conditions of their experiment. The transfer measure used was based on a comparison of the learning of the PA list preceeded by the serial list. According to Young, (1963) the results of the Horowitz and Izawa experiments do not, however, permit an unambiguous interpretation. The transfer measure used was based on a comparison of a group which had previously learned a serial list with one which had not previously learned the list. The obtained transfer might be a function of interitem associations formed during serial learning, or it might be the result of differential practice. Since either of these would be expected to produce positive transfer, Young argued that the obtained transfer cannot be conclusively attributed to the formation of interitem associations.

Though the adjacent and remote association view appeared plausable and compelling it did not satisfy Asch, Hay and Diamond (1960), who studied serial learning under conditions in which the items not only had a certain temporal order, but also had various spatial locations. Their study showed that spatial arrangements had a marked influence upon the course of learning, and that a simple chaining hypothesis could not accomodate this fact.

Ebenholtz (1963) produced evidence supporting the interpretation that position is used as a stimulus cue. This asserted that learning was much easier if an item maintained its absolute position in the list, as compared to the case in which position was varied. Thus explaining that, knowledge of an item position was seen as an important determinant sought to isolate the role of position and to test the effectiveness of knowledge or position as a mediator of serial learning. In Ebenholtz's experimental approach, the subjects were trained to discriminate between vertical array of 10 small rectangular "windows" so that given any window the subject could supply the syllable appropriate to it. On the assumption that serial learning entails the ordering of syllables with respect to temporal locations, both tasks involved a common process, i.e., position learning. Transfer from one task to the other occured readily when the syllables were ordered in similar fashion. Ebenholtz introduced the control condition in which the relation of the positions of syllables across the tasks were random, e.g., the first syllable in serial learning appeared toward the center of the spatial array, etc. This control condition was introduced to facilitate the idea that if serial learning does not entail position learning then the relative placement of syllables across the tasks should not affect the degree of transfer. A second control was introduced in which the items maintained their relative order on the two tasks but were displaced from their absolute positions. This condition premitted the evaluation of the extent to which transfer may be mediated by specific associations between adjacent items. The results yielded evidence for position learning

in serial learning and raised the question of sequential learning.

Young (1963) designed an experiment to control for the differential practice effect in the investigation of transfer from serial to PA learning found in Horowitz and Izawa (1963) study. The results did not support a theory of interitem associations formed during serial learning, but led to the suggestion that the positive transfer observed by Horowitz and Izawa may have resulted from practice effect. Young asserted that their results could not be taken as unambiguously supporting an interitem association theory of serial learning.

Two other hypotheses, combining these major hypotheses, remote association, adjacent association and position, have been suggested. One assumed a sequential stimulus for the end of the list and a positional stimulus for the middle of the list (Young, Patterson, Benson, 1963). The other assumes a positional stimulus for the end of the list and a positional stimulus for the middle position (Ebbenholtz, 1963). It appears that both investigators would allow both types of cues throughout the list, but assumed that the relative weight of the positional and sequential cue change from the ends to the middle of the list.

In attempting to assess the relative importance of sequential and positional associations in serial learning, Jensen and Rohwer (1965) compared transfer from a serial list to two different types of paired associate task. For one design, subjects learned a serial list (say A,B,C,D,...) and then a double-function list of paired associates, a list constructed from adjacent items of the serial task (A-B, B-C, C-D, ...). The control subjects learned a serial list of items unrelated to those

on the list of paired-associates. This experimental arrangement was viewed as a test of the sequential hypothesis according to which serial learning consists of the formation of associations between successive pairs of items in a list.

For the other types of design, Jensen and Rohwer's subjects learned a serial list (A,B,C,D,...) and then were given a paired associate list task that required them to associate individual items of the serial list with spatial positions in a horizontal array of rectangles (1-A, 2-B, 3-C, 4-D,...) where each number represents a spatial position in the arrays. When a red dot appeared in one of the rectangles, subjects were to respond with the item that had occupied the corresponding ordinal position in the serial list. A control group learned the same spatial paired associate task after having learned a serial list constructed of items unrelated to that transfer task. This design was conceived as a test of the ordinal-position hypothesis, according to which serial learning consists of the formation of association between individual items and their respective ordinal-positions in the list.

Jensen and Rohwer assumed that the differences in transfer effects yielded by the two designs would reflect the relative availability of sequential versus positional associations after serial learning and, in turn, reflect the extent to which the formation of associations of each type is involved in serial acquisition. The results, however, failed to provide any evidence that could be taken as support for either the sequential hypothesis or the ordinal-position hypothesis. Jensen and Rohwer were forced to conclude that neither sequential nor positional associations appear to play a very important role in serial learning.

A number of subsequent studies (Heaps, Greene and Cheney, 1968) have yielded significant transfer effect with the serial/double-function design. However, it has become clear that a major factor determining the degree of transfer with this paradigm is the length of the anticipation interval used for the paired associate learning. Studies showing significant transfer effect have used a slower presentation rate for the PA than the 2:2-sec. rate used by Jensen and Rohwer. Similarly, significant transfer effects have been reported for the serial/spatial discrimination paradigm where 3:3-sec. rate was used (Ebenholtz, 1963) although the degree to which effects may have been inflated was not taken into account by the nature of the control condition employed.

Alamecka (1967) utilized the device of providing spatial cues which were independent of the temporal serial order. The results of Slamecka's experiment failed to support expectations based upon the chaining hypothesis. Slamecka carried out four experiments which found support for hypotheses based upon perception of derived-list patterning, and were essentially incompatible with predictions based on the doctrine of remote associations. Furthermore, experiments found support for a hypothesis that the association method produces its results because of an artifact, namely differential practice on the correct responses as a result of the serial position list items. Slamecka concluded that the association method was inconclusive with regards to the question of the reality of remote associations.

Robert L. Breckenridge and Theodore R. Dixon (1970) studied the effects of differential amounts of practice with a serial list on transfer to a related task. The chaining hypothesis should predict that

positive transfer should occur when the PA list learned following serial list learning is composed of the same item associations presented in the serial list, while negative transfer should occur when the PA list is composed of the same item but different associations than those presented in the serial list. In a series of three experiments, two factors, affecting transfer were studied: the relationship of the serial list to the PA list and the amount of practice on the serial list. The three conditions of transfer were: conditions in which pairs in the PA list were composed of adjacent items in serial list, the other condition was, in which pairs of the PA list were composed of non-adjacent items in the serial list. The final condition was a control, in which items in the PA list were different from items in the serial list. Significant amounts of positive and negative transfer were obtained in the first and second conditions, respectively, at all levels of practice. This experiment shows that, not only does practice to one correct trial on the adjacent item serial list yield positive transfer, but practice to the same criterion on the non-adjacent item serial list result in significant negative transfer to the PA list. Furthermore, the data of these experiments done by Breckenridge and Dixon (1970) may be interpreted as suggesting that associations are formed between adjacent serially learned item as predicted by the associative chaining hypothesis.

On the basis of these data and those reported by Postman and Stark (1967), Shuell and Keppel (1967), it would appear that there is sufficient evidence to conclude that associative chaining does occur in serial learning.

Six years after Jensen and Rohwer's study (1965), C.J. Johnson (1971)

of University of British Columbia studied the sequential and positional cues in serial to paired associate transfer. It seemed quite likely to Johnson that the differences in relative transfer yielded by the two types of design may have been observed in the Jensen and Rhower study by the low degree of absolute transfer that was imposed by the rapid presentation of the transfer (PA) lists. In view of this possibility, the essential aspects of the Jensen and Rohwer's design were replicated in Johnson's study. In order to make conditions non-favorable for transfer, a 4:4-sec. rate was used for presentation of those lists. Also, the design was extended by including negative transfer conditions for both the sequential task and the positional task. In addition, a third sequential/positional type of transfer was administered to groups of positive, negative and control subjects. This task was constructed so that performance might be sensitive to the transfer of either sequential or positional associations as well as to a combination of the two. That is, subjects in the positive transfer condition got a positional cue and a sequential one. This combined task was included in the design to investigate the possibility that acquisition of a serial list represented a multiple cuing type of learning for which the effective stimulus is actually a complex of stimuli consisting of some combination of positional and sequential cues. The design thus included three conditions of transfer (positive, negative and control) for each three types of PA tasks (sequential, positional and sequential/ positional). Johnson's results indicated the relative positive transfer from a serial list to a PA list that was mediated by interlist positional relations was almost twice as pronounced so that mediated by interlist sequential relations. When both sequential and positional cues were

available, transfer was no greater than that with positional alone. These results are not incompatible with the assumption that sequential cues form a part of the complex pattern of perception serving as functional stimulus for at least some of the items in a serial list.

The foregoing discussion gives a brief account of the history of the serial position hypothesis. Of all the experiments listed, that carried out by Young (1962) is most pertinent for the purposes of this study. For Young's experiment four 13-item serial lists were constructed with the first item serving as a cue symbol. List A and B were experimental lists. Each subject learned one of these lists and then all subjects learned the test lists. Comparing list A with the test list, the even items in list A held the same serial positions as they did in the test list while the odd items were randomly rearranged from list A to the test list. In list B the odd items held the same serial positions as they did in the test list while the even items were randomly rearranged. In this manner, test lists differences between those items with the same serial positions and those items with different serial positions were attributable to transfer effect rather than to differential difficulty due either to specific items or to serial positions. The control list C had no items in common with the test list, and test list learning was used to evaluate transfer effects. Young used 63 subjects in the experiment, 21 in each condition.

In this experiment, transfer from two serial lists to a paired associate list was studied. The syllables from the serial lists were used to form single paired associate list. The paired associate list contained three types of pairs; same position-same pair, different

position-same pair, and different position-different pairs. For example, in SL_1, ABCDEFGH and SL_2, IJKLMNOP, B-J would be same position-same pair, C-K would be different position-same pair (that is, C-K would be in position six instead of position 3) and A-P would be different position-different pairs (see Appendix C).

The major differences between Young's experiment and the experiment carried out here is that the former measured transfer of same position items from one serial list to another serial list. In the present, transfer of same position items were observed from two serial lists to a paired associate. Furthermore, in the Young's experiment there were two levels of the independent variable; same position and different positions. This experiment consisted of three levels of the independent variables: same position-same pair, different position-same pair, and different position-different pairs.

The purpose of this paper was intended to determine whether the Young's (1962) experiment which measured transfer of same position items from one serial list to another serial list could be extended to include positive transfer of same position items from two serial lists to one paired associate list. The hypothesis of this experiment purports that same position-same pairs would be easier to learn and should have a very high proportion of correct responses in comparison to paired associates that have different serial position-same pairs and different serial positions-different pairs.

METHOD

Subjects: The subjects were 30 students from Eastern Illinois University. Some were psychology majors and did not serve previously in similar experiments. Subjects were randomly assigned to groups. Subjects were not familiar with the purpose of the experiment and the hypothesis.

Stimulus: The initial stimulus population was composed of nonsense syllables from the 8th table associate value nonsense syllables after Glaze (1928) using value 80%. Each nonsense syllable consists of "Consonant-vowel-consonant". For identification purposes in serial list 1 there were nonsense syllables with middle vowel A and E. And for serial list 2 there were nonsense syllables with middle vowels O and U.

Apparatus: A standard carousel slide projector was controlled by Hunter timers to present the stimuli at 3 secs. intervals. There was a screen which showed the items projected from the standard carousel slide projector.

Procedure: There were two stages in this experiment. In stage I, two twelve item serial lists of nonsense syllables were constructed, with each item projected on a screen by a tachistoscopically controlled carousel slide projector. In stage II, the syllables from the serial lists were used to form a single paired associate list. The PA list contained 3 types of pairs: same position-same pair, different position-same pair, different position-different pair. Furthermore, in the PA list, half of the syllables from the serial list were stimulus items and the other half wer response items. There were six different serial lists of twelve items, and three different paired associate lists (see Appendix C). There

were three groups, each group learning two different serial and paired associate lists. Subjects were assigned to lists consecutively by the order in which they appeared at the laboratory.

Instructions were read at the beginning of each stage of serial learning and PA learning.

Before each subject began their task in stage I, the experimenter read the related instructions:

> "This is a learning experiment that consists of two stages. In the first stage you will see two serial lists on a screen. Both lists will be shown alternately with each item shown for 3 seconds. The first trial is a presentation trial, then you will be tested. When you see the star on the screen you will anticipate the first item. After you have made your response, I will show you the next item regardless of whether your answer was correct or not. There will be alternated trials from list 1 and list 2 until you correctly recall both serial lists once."

After the instructions were read, the subject was allowed to ask questions if in doubt concerning the task. The two lists were shown alternately to the subject with both lists having a star as a cue to indicate that the subject should proceed with the first response. After presentation trial the subject then waited for the star. The subject saw each item for two seconds and had five seconds for each response. Subject's task was to spell each syllable aloud. Phase I continued until the subject reached a criteria of one perfect recitation of both serial lists.

Having learned the serial lists, the experimenter read the other half of the instructions for the learning of the PA list:

> "Now that you have completed the learning of both serial lists, your task is to learn a PA list. You will see the PA list and your task is to learn the association of the nonsense syllables presented on the screen. The first trial is the presentation trial,

then I will show you the stimuli and you give me
the response."

After the instructions were read, the subjects were first presented with the entire PA list as a practice trial, and then were shown the stimulus and had to give the correct response. The experimenter stopped when the subject was able to recall all PA items correctly one time.

RESULTS

The mean and standard deviation for number of trials to master the serial lists were, $\bar{x}$ = 18.2, 19.2, 19.3 and s= 2.149, 1.932, 1.316 respectively for the three groups having different lists. The analysis of variance yielded a non-significant F value of .99.

The mean percentages of correct responses for the same position-same pairs, different position-same pairs, and different position-different pairs were 78.27449, 59.1666 and 42.23332 respectively. The differences among these means were highly significant, F=222.1826, df=2. The high F value is reflected in the Ω^2 (omega squared) value, Ω^2=.34, which indicated that 34% of variation is accounted for by the difference of levels of the position main effect. The mean percentages of correct responses were plotted in Figure I. The same position-same pairs, different position-same pairs and different position-different pairs were arranged according to their ease of learning (see Figure I).

INSERT Figure I here

When so arranged the linear trend is apparent (see Figure I) and the linear orthogonal polynomial is highly significant, F=443.83. The quadratic function is not significant F=.53. The differences plotted are significantly different by Tukey, CR=1016.59.

INSERT Table I here

Table I represents the analysis of variance data for the percentages of correct responses, degrees of freedom, mean squares and Fs for the list, position, and pairs. There is a significant subject effect, F=4.8668, and a significant pair effect, F=4.8654. Lists were not significantly different and there were no significant interactions.

The presence of the three random ractors of subjects, lists, and pairs require the use of quasi Fs to derive appropriate error term for the list (B) effect and for the interaction of lists with position (A X B). The F values were, F=.137 and F=1.2028 respectively. The formula used for computing the quasi F are given in Appendix D.

DISCUSSION

The hypothesis tested in this experiment was that the position the item holds in the serial list is the effective stimulus. The hypothesis was tested by observing transfer from two serial list to a one paired associate list. The items in the two serial lists were employed in the paired associate (PA) list and were arranged so that the same position-same pair items retained the same serial positions in the two serial lists and PA list, while the different position-same pair and different position-different pair were randomly arranged from the two serial list and PA list. If the serial position was the effective stimulus, positive transfer would be expected for the same position-same pair items and different position-different pair items. The results of the experiment show that the same position-same pair items were the easiest to learn, the different position-same pair was a little more difficult to learn, but significantly better than the different position-different pair items.

Young (1962) has presented a great deal of convincing data to the effect that the stimulus for an item in a serial list is not the preceeding item at all, but that it may instead be the serial position of that item. The results in this experiment strongly support the Young's hypothesis that position is the stimulus for an item in the serial list.

The experimenter also concluded that the Young's (1962) experiment which measured transfer of same position items from one serial list to another serial list could be extended to include positive transfer of the same position items from two serial list to one paired associate list.

The data also lends support to the Ebenholtz (1963) study which has demonstrated clearly that a serial list can be learned quite satisfactorily without the necessity of forming adjacent sequential connections in the list, but rather through associating the items with their spatial positions.

Since the pairs were constructed so that adjacent items in serial learning never appeared in that order in the paired associate list, there is little support for specificity hypothesis because it would have been impossible to learn the paired associates by the acquisition of serially adjacent associations alone. So this study in addition to Young (1962) and Ebenholtz (1963) makes the specificity hypothesis questionable.

According to Young (1961), the specificity hypothesis that associations are formed between items of a serial list would make the prediction that no differences would obtain between the levels of independent variables measured in this experiment. According to the specificity hypothesis, each item was associated to a response in the first list, but in no case were the same position-same pair items in the PA list learned in the same sequence as successively in the two serial lists.

It seems likely that position may play a more important role in serial learning than sequential associations. For the purpose of argument it is important to compare the effects of transfer obtained by Young (1959) with the present study. Young's subjects first learned paired associate and then transferred to the serial list, in which pairs of successive terms were identical with those of paired associate list. If specific associative bonds were sufficient to master the serial list, then ideally, Young's subjects should have learned within one trial. Actually a mean of 8.08

trials were required to reach one correct recitation of the entire list. Since in the present study of items maintaining same position-same pair showed impressive transfer from two serial to paired associate list, it appears reasonable to conclude that position is one of the most important factors in serial learning.

In addition, this data also lends support to the Johnson (1971) study which demonstrated that acquisition of a serial list is represented by a multiple cuing type of learning. Similarly, the present experiment which consisted of a combined task (pairs and position) included in the design, demonstrated the possibility that acquisition of a serial list represented a multiple cuing type of learning for which the effective stimulus is actually a complex of stimuli consisting of some combination of positional and pairing (association of pairs) cues.

Finally, the data of this experiment provides the evidence that it is not only same position items that cause positive transfer from serial to paired associate list, but also the same paired items, since different position-same paired items were learned significantly better than different position-different pairs. Young (1962) could not have provided this result since the design for his experiment was only limited to two levels of the independent variable (same position and different position) and transfer was measured only from one serial list to another. A proposal for further research on this topic would be to include a separate group of subjects and have them learn the paired associate list without learning the serial list. In so doing, it would be anticipated that there would be a significant difference between subjects having paired associates alone, and subjects learning both serial list and paired associate list.

APPENDIX

Appendix: The appendix includes items and data sheets

APPENDIX B

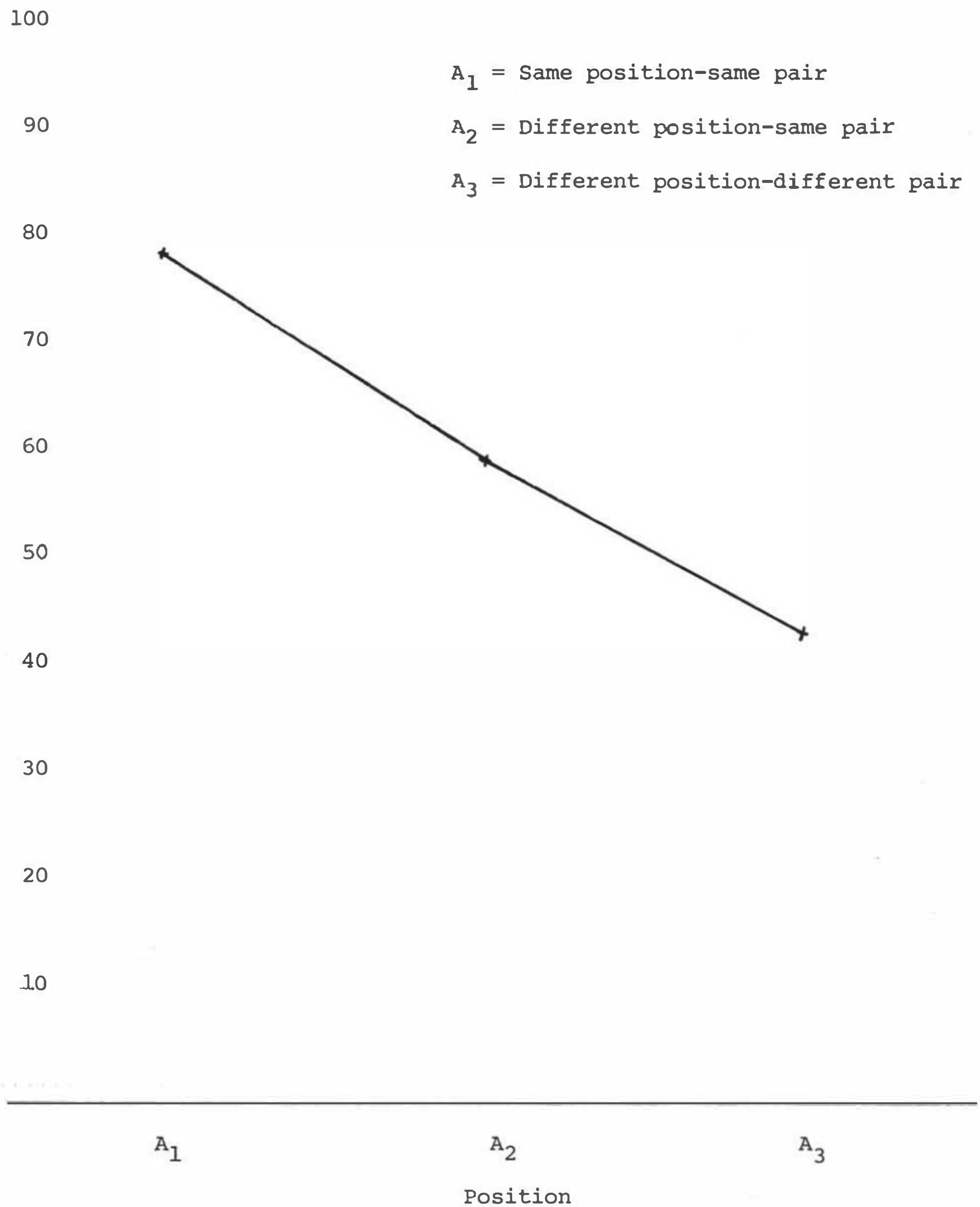

Figure I: Mean percentage correct in paired associate learning for the three different pairs.

APPENDIX B

TABLE I: Analysis of variance for dependent variable which is the percentages of correct responses of each type of pair.

Source	df	Mean Squares	F
B (list)	2	2502.57	1.2028 +
Subjects in B	27	1159.593	4.8668 *
A (position)	2	39017.34	222.1826 **
B X A	4	175.6094	0.137 +
Pairs in B X A	27	1159.259	4.8654 *
S X A in B	54	359.3711	1.5083
S X C in B X A	243	238.2665	

* $p < .05$

** $p < .001$

+ Quasi F

APPENDIX C

List A	List B	List C
JEM	PEL	LAT
FER	DEL	MAJ
VAX	GAM	JEM
NAS	WEN	LEM
HAW	MAC	RAF
CEL	LAV	MAB
DAW	HET	PAM
SEN	TEQ	DAP
GEL	NEB	TAS
YEP	CAV	SEK
WES	YEH	VEW
DEV	SAN	REN

LOD	GOS	DUT
GOR	FOS	NOZ
HUP	FUD	DOW
YON	LOX	GUZ
KOF	JOS	KOL
RON	HUV	HOL
FOD	TUX	JOR
MUC	SOM	FOK
WUD	KOL	MOT
TUS	BUC	LOR
SOY	WUL	BOD
SOM	MAZ	POM

$\propto$ NAS-YON	o HET-LOX	- LAT-DUT
- FER-GOR	- WUL-YEH	o VEW-FOK
o DEV-HUP	$\propto$ GAN-FUD	$\propto$ REM-POM
$\propto$ YEP-TUS	o TUX-CAV	- LEM-GUZ
- HAW-KOF	- TEZ-SOM	o MAJ-BOD
o VAX-BOM	$\propto$ HUV-LAV	$\propto$ TAS-MOT
$\propto$ JEM-LOD	o WEN-GOS	- PAM-JOR
- SEN-MUC	- JOS-MAC	o RAF-NOZ
o CEL-WUD	$\propto$ NEB-KOL	$\propto$ MAB-HUL
$\propto$ DAW-FOD	o BUC-PEL	- SEK-LOR
- WES-SOY	- DEL-FOS	o DAP-KOL
o GEL-RON	$\propto$ MAZ-SAN	$\propto$ JEM-BOW

- = same position-same pair
$\propto$ = different position-same pair
o = different position-different pair

APPENDIX D

Formulae for Quasi F_B and F_{AB}

$$F_B = \frac{MS_B}{MS_{S/B} + MS_{C/AB} - MS_{SC/AB}}$$

$$F_{AB} = \frac{MS_{AB}}{MS_{C/AB} + MS_{SA/B} - MS_{SC/AB}}$$

REFERENCE

Asch, S. E., Hay, J. and Diamond, Rhea M., "Perceptual Organization in Serial Remote Learning", American Journal of Psychology, 1960, 73, 177-98.

Brekendridge, R. and Dixon, T., "Problem of the Stimulus in Serial Learning", Journal of Experimental Psychology, 1970, 83, pp. 126-130.

Ebbinghaus, H. E., "A Contribution of Experimental Psychology", 1885, (H. A. Reiger and C. E. Bussmeus, Jr.) New York: Teachers College, Columbia University, 1913.

Ebenholtz, S. M., "Position Mediated Transfer Between Serial Learning and a Spatial Discrimination Task", Journal of Experimental Psychology, 1963.

Glaze, J. A., "The Association Values of Nonsense Syllables", J. genet. Psychology, 1928, 25, pp. 255-69.

Horowitz, L. M. and Izawa, C., "Comparison of Serial and Paired Associate Learning", Journal of Experimental Psychology, 1963, 65, pp. 351-62.

Jensen, A. R. and Rohwer, W. D., Jr., "What is Learned in Serial Learning?", Journal of Verbal Learning and Verbal Behavior, 1965, 4, pp. 62-72.

Johnson, G. J., "E-fects of Item Discriminability in Mixed List Presentation of Paired Associates", Psychonomic Science, 1970, 21, pp. 371-373.

Lashley, K. S., "The Problem of Serial Order Behavior", in L. A. Jeffres (ed), Cerebral Mechanisms in Behavior, New York: Wiley, 1951, pp. 121-136.

Postman, L. and Stark, K., "The Effects of Interitem Associative Strength on the Acquisition and Retention of Serial List", Journal of Verbal Learning and Verbal Behavior, 1962, 1, pp. 484-490.

Slamecka, N. J., "An Inquiry into the Doctrine of Remote Association", Psychological Review, 1964, 71, pp. 61-76.

Shuell, P. J. and Keppel, E. I., "The Chaining Hypothesis of Serial Learning", Journal of Verbal Learning and Verbal Behavior, 1967, 6, pp. 439-445.

Young, R. K., "A Comparison of Two Methods of Learning Serial Associations", American Journal of Psychology, 1962, 53, pp. 127-142.

Young, R. K., "Test of Three Hypotheses About Stimulus on Serial Learning", Journal of Experimental Psychology, 1962, 62, pp. 307-313.

Young, R. K., Milauckas, E. W. and Bryan, J. D., "Serial Learning as a Function of Prior Paired Associate Learning", American Journal of Psychology, 1963, 76, pp. 82-88.

Young, R. K., Patterson, J. and Benson, W. M., "Backward Serial Learning", Journal of Verbal Learning and Verbal Behavior, 1963, 1, pp. 335-338.