CONSTANT VERSUS VARIED SERIAL ORDER IN PAIRED-ASSOCIATE LEARNING AS A FUNCTION OF INTRALIST SIMILARITY

by

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Research in verbal learning has traditionally maintained a sharp distinction between _serial_ and _paired-associate_ learning. In serial learning, the subject is required to learn the order of a series of items, and this order remains the same from trial to trial. In paired-associate (PA) learning, the subject is presented with several different pairs of items and is required to associate the two members of each pair together. In order to avoid any possible confounding effects of serial order which might occur if the pairs were left in the same serial positions from trial to trial, standard procedure in studies of PA learning has been to vary randomly the order of presentation of the pairs on each trial (e.g., McGeoch & Irion, 1952, p. 15). Underwood (1963) has also recently stated ".... that if the pairs of a standard paired-associate list are presented in the same order, trial to trial, the subject will quickly abandon paired-associate learning and will learn the response terms as a serial list (p. 42)." However, the question as to whether subjects do, in fact, learn a PA list as a serial list under conditions of constant serial order cannot yet be easily answered. Not only is the evidence bearing directly upon this issue very limited, but it is often conflicting. Moreover, of the studies which have investigated the problem, few have been systematic in nature, and little, if any, attempt has been made to specify the precise conditions under which constant serial order may affect PA learning.

McGeoch and McKinney (1937) were the first to investigate the problem empirically. Using a Recall-5 presentation method (five successive pair presentation trials followed by a single recall or test trial) they found that presentation of the pairs in a constant order led to faster learning than did pair presentation by the usual varied order procedure. McGeoch and Underwood (1943) essentially replicated these findings using the anticipation method with testing on every trial. Specifically, they found that not only was the constant list learned faster than the varied list, but the initial and final portions of the constant list were learned first; a phenomenon characteristic of serial learning. Also, many subjects reported that they learned the lists in serial order. From these findings, the authors concluded that there was evidence ".... supporting the interpretation that serial learning was employed by many of the subjects, either in learning the entire list or in learning portions of the list (p. 12)." Following the McGeoch and Underwood study in 1943, research on serial position effects in PA learning received little attention until the work of Newman and Saltz (1962). Although Newman and Saltz confirmed the findings of significantly better PA performance under constant than varied serial order using the Recall-5 procedure as employed by McGeoch and McKinney (1937), they found this facilitative effect to be as great when the serial order of the stimulus terms during the test trials differed from the constant order used during learning trials (random test) as when the same constant order was used on both learning and test trials (serial test). These results would seem to suggest that serial learning of the pairs (or response terms) was not the only factor responsible for the facilitation produced by constant serial order. However, Martin and Saltz (1963) point out that the lack of difference between serial and random test groups in the Newman and Saltz study may have been due to the insensitivity of the latter test situation which employed just a single test trial. Furthermore, recent findings by Newman (1965a), using the same procedure as Newman and Saltz except with testing after the fifth, tenth, and fifteenth pairing trials, lends support for the contention of insensitivity. Newman found that while there was no significant difference between the random and serial test groups on the first test trial, significantly better performance occurred under the serial test, as compared to both random test and a varied serial order group, on the second and third test trials. In still another study, with test trials following each pairing trial, Newman (1965b) found that constant serial order led to faster learning than varied serial order. Furthermore, results from both of Newman's studies (1965a; 1965b) based on the free recall of the PA response terms following PA learning, further suggest that the facilitation observed during training was due at least, in part, to learning of the response terms in serial order.

To provide for a more sensitive test of the serial cue hypothesis (e.g., learning of the response terms in serial order), Martin and Saltz (1963) performed two related studies also using the Recall-5 procedure, but with test trials at the end of the fifth and tenth pairing trials. Contrary to the findings of previous research, these investigators failed to obtain, in both studies, significant facilitation of constant over varied serial order PA learning. However, they did find significant facilitation for subsequent serial learning of the PA response terms when these were presented in the _same_ order as in the PA list, as compared with an order _different_ from that used in the PA list. Thus, even though constant serial order had no apparent overall effect on PA performance, the positive transfer to subsequent serial learning would seem to indicate that something had been learned about the serial order of the response terms. It should be pointed out, however, that Martin and Saltz did not use a needed second control group (i.e., transfer of the varied serial order group to serial learning), which would have allowed for a measure of absolute transfer from PA to serial learning. It may well have been that the superiority of the Same over the Different order group was due primarily to negative transfer in the Different order group.

By holding serial position of pairs partially constant, Brown and Battig (1962) investigated the role of serial position cues while preventing actual serial learning. By holding less than half of the pairs in a PA list constant in non-adjacent serial positions on all trials, while the rest of the pairs appeared in different positions on each trial, they found significantly better performance than with a completely varied condition. However, they found that this facilitation occurred if pairs were held constant only after being responded to correctly for the first time, which indicated that serial position cues might become important only after the initial formation of associations between the stimulus and response members of a pair. In a further series of studies, Battig, Brown, and Nelson (1963) concluded that while PA learning was significantly facilitated by the use of a constant serial order of pair presentation, the effect was of a relatively small magnitude and limited primarily to the later stages of learning. In fact, these investigators failed to find any significant facilitation due to constant serial order in two of five studies. Furthermore, in analyzing PA learning, they found nothing that resembled the classical serial position curve, and no superiority of subsequent serial learning of either stimulus or response terms presented in the same serial order as in the PA list, as compared with serial lists using different orders. This last result is in direct contrast to the results of Martin and Saltz (1963).

From the research discussed above, it is clear that a general facilitation of PA learning produced by constant serial order has not been convincingly demonstrated; only minimal effects have been found in most cases. Moreover, results from these studies offer little empirical or theoretical basis for delineating parameters whose systematic investigation might aid in a more detailed specification of the conditions under which constant serial order facilitates PA learning, and of the mechanism(s) responsible for its effect. The purpose of the present research was to offer a theoretical formulation based upon formal intralist stimulus and response similarity which not only allows for the partial systematization of previous research, but empirical tests of predictions which can be made from this formulation.

The use of highly confusable, unfamiliar terms in the stimulus position of a pair has been generally shown to lead to considerable difficulty in learning stimulus-response connections (Deese, 1958; p. 207-208). Since in the typical PA task the subject is asked to elicit from memory only the response and not the stimulus term, under conditions of both constant serial order and high inter-stimulus similarity, the subject may tend to ignore the stimuli and instead learn the response terms in serial order. Under conditions of high interresponse similarity, however, learning of the response terms in serial order should be discouraged and subjects might rely more heavily upon stimulus-response connections in order to master the list. Although it is difficult to predict precisely what effect high or low stimulus similarity would have on constant serial order PA learning when these are combined with high or low similarity response terms, it is nevertheless possible to make several specific predictions about some of these possible combinations. As previously mentioned, maximum facilitation with constant serial order should occur with high stimulus-low response, intralist similarity since this condition would tend to maximize the use of serial cues and minimize the use of PA cues. Conversely, the conditions wherein constant serial order should have the least effect should occur with low stimulus-high response intralist similarity, since this condition would tend to minimize serial cues and maximize the use of PA cues. In the case of high stimulus-high response and low stimulus-low response intralist similarity, it is much more difficult to make predictions. The use of high stimulus-high response similarity would tend to minimize the use of both serial and PA cues, and either one, or both, may become dominant in learning. The use of low stimulus-low response similarity may also result in the use of either one or both of the cues since both are readily available.

The above formulation also appears consistent with

Underwood's (1963) treatment of nominal and functional stimuli in verbal learning. Underwood has stated that a nominal stimulus is "the stimulus term presented to the subject" while the functional stimulus is ".... the characteristic or characteristics of the stimulus which the subject actually 'uses' to cue a response (p. 33)." Since a subject could use any of several cues available to him, it would appear that as the difficulty of using any one cue increases, the subject would tend to utilize more and more of the other available cues in the learning process. Therefore, the subject may tend to use serial position cues as functional stimuli when high intralist stimulus similarity renders the nominal stimulus terms difficult to use in the associative process. Conversely, the subject may rely more heavily on the PA stimulus terms as functional stimuli when serial position cues are rendered relatively nonfunctional due to high intralist response similarity.

In an attempt the evaluate previous constant serial order PA learning studies in terms of the above stated similarity hypothesis, the materials used by past investigators, together with their findings, were classified with respect to variations in intralist stimulus and response similarity. Newman (1965a) and Newman and Saltz (1962) used nonsense syllable-noun pairs. They constructed their lists so that there was high interstimulus similarity (through the use of a limited number of consonants). Since they used nouns as response terms, it is difficult to evaluate formal response similarity. However, since these nouns were selected to minimize associative relationships among the response terms, it will be assumed that the nouns were of low intralist response similarity. Thus, according to the present formulation, their lists corresponded to high stimulus-low response similarity. Both of these studies found constant order facilitation. Brown and Battig (1962) and with the exception of one experiment to be described below, Battig et. al. (1963), used nonsense syllables in both the stimulus and response positions of their pairs. Minimal intralist stimulus and response similarity was maintained in all lists. Thus, all the lists were of low stimulus-low response similarity. Both of these investigators found only marginal facilitation of constant serial order. Martin and Saltz (1963) used low intralist similarity nonsense syllables as stimuli and nouns as response terms. These investigators failed to find any significant facilitation of constant serial order using what roughly corresponded to low stimulus-low response similarity lists. It was impossible to determine from the literature how the other investigators constructed their lists. McGeoch and McKinney (1937) used nonsense syllable-noun pairs while McGeoch and Underwood (1943) used noun-noun pairs. In both cases, the authors did not state how their lists were constructed, although both did find facilitation due to constant serial order. Newman (1965b) used tactual geometric stimuli and single letter consonant responses while Battig et. al. (1963), in one experiment, used nonsense shape stimuli and two digit numbers as responses. No quantitative measurement of intralist similarity could be made in either of these two studies. In summary, then, when it has been possible to evaluate intralist similarity, it appears that constant serial order facilitation has occurred when high stimulus-low response similarity terms have been used (Newman, 1965a; Newman and Saltz, 1962) and marginal or no facilitation has occurred when low stimulus-low response similarity terms have been used (Brown and Battig, 1962; Battig et. al., 1963; Martin and Saltz, 1963). Thus, while the results of previous research are in general accord with expectations derived from the present analysis based upon stimulus and response intralist similarity, this analysis is necessarily post hoc and therefore of limited generality. In order to test empirically the present intralist similarity hypothesis, the following study was conducted.

METHOD

Subjects

The 80 subjects (Ss), 55 males and 25 females, were enrolled in the spring semester general psychology classes at Kansas State University and received credit for their participation which was applied toward their final grade in the course. Each S served for a single session of two hours or less. Data from one additional S were discarded for failure to try to learn the list.

Paired-associate Learning

All Ss learned a list of 12 nonsense-syllable pairs to a criterion of two successive errorless trials using the recall method of PA learning (e.g., Battig & Brackett, 1961). Each learning trial consisted first of the individual presentation of all 12 pairs of the list, contained on 2 x 2 in. slides, through an automatic slide projector, followed immediately by a recall series, during which only the first (stimulus) syllable of each pair was exposed, and S attempted to spell the appropriate response syllable which was previously paired with it. All overt responses made by S were recorded on the data sheet. During the recall series, a shutter operated by the experimenter (E) was lowered over the projection screen so that only the stimulus member of each pair was exposed.

Based on order of appearence in the laboratory, Ss were unsystematically assigned to one of two Constancy groups of 40 Ss each. For the Constant (C) group, the 12 pairs of the list were always presented in the same order on each trial. For the Varied (V) group, the pairs were always presented in a different order on each trial, although order of pair presentation was the same for both the presentation and recall series within each trial. In addition, one-quarter of the Ss (10) within the C and V group learned each of four different PA Lists. These Lists differed from one another in terms of variations in High (H) and Low (L) Stimulus (S) and Response (R) similarity and will be referred to as the Low S-Low R Similarity (LL), High S-High R Similarity (HH), Low S-High R Similarity (LH), and High S-Low R Similarity (HL) lists.

Upon entering the experimental room, each S was seated in front of a projection screen, which shielded him from E and the apparatus, and was given, via tape recorder, usual instructions for PA learning (see Appendix 1). No mention was made of either the criterion of performance to be reached, or whether the pairs would be presented in C or V orders from trial to trial.

For Ss in the C group, 10 different constant orders of pair presentation were used (randomly selected from a 12 x 12 balanced latin square), with each of the 10 Ss in each List condition learning one of the 10 orders. The same 10 orders also served as the basis for pair-presentation order in the

V group, but with a different one of the 10 orders being used on each of the first ten trials. The particular sequence in which the 10 orders were administered to each V S was unsystematically determined before S appeared in the laboratory. In the event that S did not reach criterion after completion of the tenth trial, the same sequence was repeated until E terminated PA learning.

A 5-sec. presentation rate (4-sec. exposure, 1-sec. between successive slides) was maintained throughout each trial, with a 15-sec. interval between trials and between alternating presentation and recall series within each trial. Under the V condition, the slides were rearranged for presentation on each trial after the recall series was completed.

Serial Learning

After completing PA learning, all Ss were allowed a one minute rest interval. During this time, each C S within each of the four List conditions was assigned to one of two serial learning transfer groups on the basis that number of Ss (5) and total trials to criterion on PA learning be approximately matched for each subgroup. For both groups, the serial list consisted of the same 12 response terms as used in PA learning. However, for Ss in the Same group, these response terms appeared in the same order as that used in PA training, whereas for Ss in the Different group, the 12 response terms appeared in an order different from that used in PA learning. Ss in the V group also learned a serial list comprised of the 12 response terms which they studied during PA training. Each of 10 different Random serial lists, corresponding exactly to each of the five Same and five Different serial lists, was used approximately equally often across the V Ss. However, it was not until after seven V Ss had been run on PA learning that the decision was made to also transfer the V group to serial learning. Five additional V Ss were also eliminated from the serial task (4 in list HH & 1 in list LH) for failure to reach the two-errorless trial criterion on the PA list within the allowed two-hour session.

Following the one minute rest interval, all Ss learned the serial list using the anticipation procedure. Using the same apparatus as employed during PA learning, each of the 12 (response) syllables was presented one at a time, at a 5-sec. rate, and S was required to anticipate the syllable which came immediately after the one that he was viewing. The successive presentation of all 12 syllables constituted a trial, and an asterisk placed at the beginning of the list served as a cue for the start of a trial. A 15-sec. rest interval was maintained between each trial. All Ss were given standard instructions for serial learning (see Appendix 1), except that they were told that the syllables to be learned would be the same as the 12 response syllables used in the previous PA task. Although no mention was made of the particular order in which the syllables would appear, Ss were urged to guess on the first trial if they thought they knew where a particular syllable would appear in the serial list. All Ss were required to learn the serial list to a criterion of two-successive errorless trials or to a maximum of 20 trials. All other procedural details were the same as those described under PA procedure.

Materials

Two sets of 12 High-similarity nonsense syllables (H_1 and H_2) were selected from Archer's (1960) calibration of association values for CVC trigrams. Each set was constructed with the use of only four consonants and two vowels with no letter duplication between the two sets. The range of association values for H_1 and H_2 was 37 - 81% and 39 - 74%, respectively, with means of 55.6% and 57.9%, respectively. For the 24 syllables comprising the two Low-similarity sets (L_1 and L_2), all vowels and all but five consonants were used within each set. Range and mean association values corresponded exactly to those of the two High-similarity sets. These four sets were then combined so as to yield two lists each of HL similarity (H_1L_1 and H_2L_2), LH similarity (L_1H_1 and L_2H_2), HH similarity (H_1H_2 and H_2H_1), and LL similarity (L_1L_2 and L_2L_1). Each of the two lists within each PA list condition was learned by an equal number of Ss (5). Formal similarity between S- and R-terms within the HH, HL, and LH lists was kept minimal through elimination of all duplication of consonants between the S- and R-terms within each of these lists. In addition, different vowels were used for the S- and R-terms comprising the HH lists. However, due to the constraint of a limited alphabet, some letter duplication between S- and R-terms could not be avoided in the LL lists.

All lists were constructed to minimize <u>intrapair</u> similarity through the use of no overlap of letters between the S- and R-members of each pair within a list. Average pair association value for the HH and LL lists both were 56.8%. Average pair association value for the H_1L_1 (L_1H_1) and H_2L_2 (L_2H_2) lists was 55.4% and 57.6%, respectively. The four basic PA lists are given in Appendix 2.

RESULTS

Paired-associate Learning

Number of errors on PA learning, the principal dependent variable, was tabulated separately for each S on each individual nonsense-syllable pair. These scores were subsequently subdivided into errors preceding and following the first correct response to each pair, which will be referred to as before and after-errors, respectively. The procedure for computing the two latter measures was as follows: Before-errors consisted of the total number of errors preceding the first correct response for all pairs in a given list, tabulated separately for each S. When computing after-errors, however, the measure of performance was the percentage of trials on which errors were made after the first correct response. For example, if (for a given S), a total of 5 errors was made after the first correct response to any or all of the 12 pairs in a particular list, and the total number of item presentations following the first correct response to the variuos pairs was 20, then the percentage of errors made after the first correct response was 25% (i.e., 5/20). Since five V Ss did not reach the two-errorless trials criterion on Part I, percentage of after-errors was employed to correct for the possible bias resulting from the decrease in the number of opportunities for errors to occur as trials preceding the first correct response (before-errors) increases (Brown, 1964).

In addition to total, before-, and after-error measures, number of trials to reach the two-errorless criterion as well as number of errors made on each trial, was tabulated for each S, all of which will be described in more detail at a later point.

The mean number of total errors made by the C and V groups under each of the four lists are presented in Part I of Table 1. As can be seen, fewer total errors were made under the C than under the V condition. Moreover, as indicated in Table 2, this C-V difference was found to be significant by analysis of variance beyond the .05 level, the minimal criterion of significance for all analyses to be reported. However, the superiority of the C over the V group can be seen to vary differentially in extent and magnitude across the four lists. Specifically, the difference in performance between the C and V condition was greatest under the HH (116.1) list, and thereafter decreased for the HL (75.1) and LH (27.0) list, with performance under the LL (-2.8) list virtually identical for the C and V conditions. As also shown in Table 2, this interaction of Constancy with Lists also proved to be significant. In this connection it is also interesting to mention that despite the substantial superiority of the LL over the HL list under the V condition, insignificantly fewer errors were made on the HL as compared with the LL list under the C condition. Additional analyses showed only the C-V

Table 1

Mean performance measures on paired-associate learning.

	List	Constant	Varied	Total
Part I Total Errors	HH	83.4	199.5	141.5
	HL	35.0	110.1	72.6
	LH	69.5	96.5	83.0
	LL	49.5	46.7	48.1
	Total	52.4	113.2	
	List	**Constant**	**Varied**	**Total**
Part II Before-Errors	HH	59.7	119.3	89.5
	HL	30.0	70.4	50.2
	LH	52.4	63.3	57.9
	LL	43.1	38.6	40.9
	Total	46.3	72.9	
	List	**Constant**	**Varied**	**Total**
Part III After-Errors	HH	.25	.35	.30
	HL	.19	.25	.22
	LH	.25	.20	.21
	LL	.21	.20	.21
	Total	.23	.27	
	List	**Constant**	**Varied**	**Total**
Part IV Trials To Criterion	HH	16.9	32.8	24.9
	HL	9.5	24.3	16.9
	LH	16.1	21.5	18.8
	LL	11.7	13.5	12.6
	Total	13.6	23.0	

Table 2

Analysis of variance summary table for paired-associate learning based on total errors.

Source	df	Mean Square	*F* Ratio
Total	79		
Groups	7		
Constancy (C)	1	4833.038	15.59*
Lists (L)	3	2611.507	8.42*
S	1	2863.504	9.23*
R	1	4489.350	14.48*
S x R	1	481.667	1.55
C x L	3	1146.785	3.70*
C x S	1	2905.140	9.37*
C x R	1	445.196	1.44
C x S x R	1	90.018	< 1
Error	72	310.122	

* Significant at or beyond the .05 level.

differences within the HH and HL lists to be significant, F's (1,72) = 18.11 and 7.58, respectively (all other F's < 1).

In order to evaluate directly the effects of variation in S and R Similarity on C and V performance, number of errors made on the two High-S (HH,HL), Low-S (LL,LH), High-R (HH,LH), and Low-R (LL,HL) lists were combined and analyzed in a variety of ways. Table 3 shows the mean number of total errors made under each S and R Similarity condition, separately for the C and V groups. As can be seen, the difference between C and V performance varied considerably across the four similarity conditions. Under High-S Similarity, substantially fewer errors were made under the C than under the V condition, whereas for the Low-S Similarity lists, this C-V difference was practically eliminated, primarily due to the fact that performance on Low-S was no better than that displayed for the High-S Similarity lists under the C condition. Moreover, this interaction of Constancy with S Similarity was found to be significant (see Table 2). Although this same High to Low reduction in C-V differences was also evident for R Similarity, the effect was of a lesser magnitude than that obtained for S Similarity, and both the Constancy x R and Constancy x S x R interactions fell far short of significance. Additional analyses showed significant differences between C and V conditions within High-S and High-R similarity lists, F's (1,72) = 24.56 and 13.76, respectively, and a near

Table 3

Mean total errors on constant and varied paired-associate learning for each stimulus and response similarity condition.

Similarity		Constant	Varied	Diff. Score	Total
Stimulus	High	59.2	154.8	(95.6)	107.0
	Low	59.5	71.6	(11.1)	65.6
Response	High	76.5	148.0	(71.5)	112.3
	Low	42.3	78.4	(36.1)	60.4

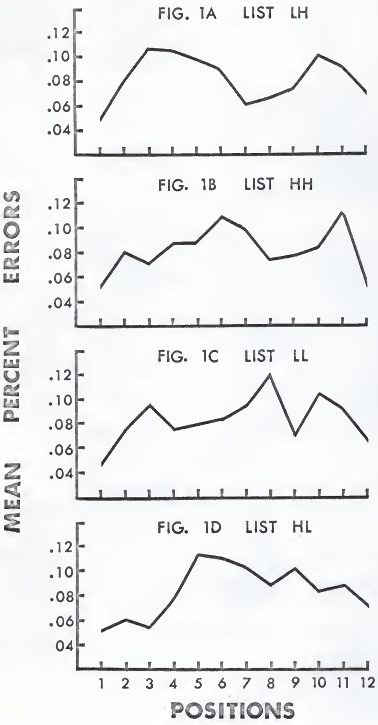
significant effect for the Low-R similarity lists, F (1,72) = 3.51; $p < .10$. However, the difference betweem C and V performance for the Low-S similarity lists failed to even approach significance ($F < 1$). From these results, as well as those based upon the individual list comparisons previously described, it may be concluded that while Low-S similarity had little, if any, differential effect on the performance of the C and V groups, the superiority of the C over the V group increased progressively from Low-S to Low-R and High-R similarity lists, with maximal facilitation under the High-S similarity lists.

As shown in Table 2, High-S and R Similarity conditions each showed significantly (see Table 3) more overall errors than under Low-S and R Similarity conditions, respectively. However, the S x R interaction failed to reach significance indicating that the effects of High and Low similarity did not vary differentially across S and R Similarity.

Virtually the same relationships as found with total errors were also obtained for measures of before and after-errors, and number of trials required to attain the two-errorless recitation on PA learning. While these data were not subjected to statistical analysis, the means of these three additional measures are presented in Parts II, III, and IV, respectively, of Table 1. Also, statistical analyses were not performed upon learning curves since inspection of these curves for the C and V groups under each list and S-R similarity condition offered little indication that performance between the various conditions varied differentially over trials.

Serial position curves for the C group were analyzed in an attempt to determine if performance on the 12 pairs within the four PA lists varied differentially in different serial positions. For the V group, a serial position analysis was not possible since no accurate measure of serial position difficulty could be obtained due to the interchanging of pairs with positions on every trial. Following a procedure described by McCrary and Hunter (1953), total number of errors made in each serial position by each S was converted to a percentage of the total errors made by that S across all positions. This procedure was used so as to permit more direct comparison of the relative difficulty of learning in each serial position for the various C conditions.

Presented in Figures 1A-1D are the mean percent errors made in each serial position under the C condition for lists LH, HH, LL, and HL, respectively. An increase in errors in beginning positions followed by a subsequent decrease in errors in end positions is shown for all four curves, with a further decrease in errors in positions just to the right of the middle of the list primarily for lists LH and HH. These data were also subjected to extended-trend analysis of variance (Grant,1956), and is presented in Table 4.



Figures 1A, 1B, 1C, and 1D. Mean percent errors made in each serial position under the C condition on paired-associate learning for lists LH, HH, LL, and HL, respectively.

Table 4

Analysis of variance summary table for paired-associate learning on percent errors, for the constant group only.

Source	df	Mean Square	F Ratio	Error Term
Total Within Ss	440	1.20177		
Position	11	.00874	3.38*	(1)
Linear	1	.01235	3.10	(2)
Quadratic	1	.05554	20.88*	(3)
Cubic	1	.00246	1.05	(4)
Quartic	1	.00842	3.05	(5)
Residual	7	.00248	1.00	(6)
Lists x Pos.	33	.00249	<1	(1)
Linear	3	.00117	<1	(2)
Quadratic	3	.00178	<1	(3)
Cubic	3	.00261	1.11	(4)
Quartic	3	.00854	3.09*	(5)
Residual	21	.00190	<1	(6)
S x Pos.	11	.00353	1.37	(1)
Linear	1	.00059	<1	(2)
Quadratic	1	.00268	1.01	(3)
Cubic	1	.00148	<1	(4)
Quartic	1	.01365	4.94*	(5)
Residual	7	.00291	1.18	(6)
R x Pos.	11	.00215	<1	(1)
Linear	1	.00289	<1	(2)
Quadratic	1	.00268	1.01	(3)
Cubic	1	.00439	1.87	(4)
Quartic	1	.00662	2.40	(5)
Residual	7	.00100	<1	(6)
S x R x Pos.	11	.00181	<1	(1)
Linear	1	.00003	<1	(2)
Quadratic	1	.00001	<1	(3)
Cubic	1	.00197	<1	(4)
Quartic	1	.00535	1.94	(5)
Residual	7	.00179	<1	(6)
Error	396	.00258 (1)		
Linear Error	36	.00398 (2)		
Quadratic Error	36	.00266 (3)		
Cubic Error	36	.00235 (4)		
Quartic Error	36	.00276 (5)		
Residual Error	242	.00247 (6)		

* Significant at or beyond the .05 level.

This analysis revealed the overall bowed-shaped curvature of the HL, LL, and HH serial position functions to be statistically reliable as evidenced by a significant quadratic component in each case, F's (1,36) = 10.17, 4.99, and 4.99, respectively. However, the quadratic component of the LH-list function failed to reach significance, F (1,36) = 1.53. Although the overall interaction between Lists and Positions and the quadratic and cubic components of this interaction did not reach significance, differences among the curves in difficulty of learning in middle serial positions was statistically substantiated by a significant quartic component of the Lists x Positions interaction. Additional tests based upon overall trend revealed only the quartic component of the LH-list function to be significant, F (1,36) = 6.75, (all other F's $\leq$ 1.88). The serial position curve for the LL list also developed a relatively large quartic component and analyses based upon High and Low S-R Similarity showed the quartic component to be significantly larger in Low as compared to High-S Similarity lists, F (1,36) = 4.94. Differences in magnitude of the quartic component between High and Low-R Similarity lists were not significant, ($F \leq$ 2.40).

Serial Learning

As previously explained in the method section, Ss in the C group were subdivided into Same and Different groups on serial learning. In order to evaluate statistically the success of the matching procedure, the means of the matching scores, as also explained in the method section, were calculated for the Same and Different groups under each of the four PA list conditions. These means together with their respective standard deviations are presented in Table 5. As can be seen, little difference existed between the Same and Different groups across the four lists. These data were also subjected to analysis of variance. Since the results of this analysis failed to reveal either significant differences between Same and Different groups or an interaction of this variable with Lists (all F's < 1), it may be concluded that any differences between the two groups in initial PA learning ability were inconsequential.

Table 5

Mean and standard deviation of matching scores for each list condition under Same and Different transfer groups.

Transfer Condition		List			
		HH	LL	HL	LH
Same	Mean	16.8	12.6	9.0	14.8
	SD	4.8	4.9	1.4	6.5
Different	Mean	17.0	10.8	10.0	17.4
	SD	5.9	4.8	3.2	5.0

The mean number of total errors made on serial learning by the Same, Different, and Random groups are presented in

Part I of Table 6, separately for each list condition. A summary table of the analysis of variance performed on these data is given in Table 7. As can be seen from Table 6, Ss under the Same condition made significantly fewer total errors than did Ss under both the Different, F (1,56) = 24.90, and Random condition, F (1,56) = 26.64. Thus, serial learning of the PA R-terms was faster when these were presented in the same constant order as used during PA learning than when presented in an order different from that used during PA learning. Moreover, performance by the Ss who had previously learned a Varied order PA list was no worse than that for Ss who learned the R-terms in a different order from that used in constant order PA learning. By reference to Table 6, it can be seen the fewest errors occurred in the HL list followed by an increase in errors in the LL list through the HH list, with most errors in the LH list. The large number of errors in the LH list appears primarily attributable to performance under the Different and Random conditions. However, as indicated in Table 7, this Lists x Transfer interaction was not significant.

Table 8 shows the mean number of total errors made under each S and R Similarity condition separately for the Same, Different, and Random groups. It can be seen that the inferiority of High over Low-R Similarity increased from Same (15.6) through Different (40.2) and Random (60.3) conditions. As shown in Table 7, this Transfer x R-Simi-

Table 6

Mean performance measures on serial learning.

Part I	Transfer Condition	Lists HH	LL	HL	LH	Total
Total Errors	Same	32.0	18.8	9.6	27.6	22.0
	Different	64.6	50.6	50.4	116.8	70.6
	Random	89.6	44.2	41.1	112.6	68.5
	Total	62.1	38.9	34.9	88.8	

Part II	Transfer Condition	Lists HH	LL	HL	LH	Total
Before-Errors	Same	16.8	11.6	6.6	20.2	13.8
	Different	43.0	40.2	42.8	83.6	52.4
	Random	65.6	32.0	32.3	79.6	50.0
	Total	41.8	28.6	28.1	63.3	

Part III	Transfer Condition	Lists HH	LL	HL	LH	Total
After-Errors	Same	.16	.18	.15	.12	.15
	Different	.29	.25	.26	.33	.28
	Random	.27	.25	.22	.36	.28
	Total	.24	.23	.21	.28	

Table 7

Analysis of variance summary table for total errors on serial learning.

Source	df	Mean Square	*F* Ratio
Total	67		
Groups	11		
Transfer (T)	2	1323. 463	16.75*
Lists (L)	3	890.665	11.27*
S	1	357.780	4.53*
R	1	2184.542	27.64*
S x R	1	129.643	1.64
T x L	6	150.379	1.90
T x S	2	43.024	<1
T x R	2	334.417	4.23*
T x S x R	2	73.695	<1
Error	56	79.037	

* Significant at or beyond the .05 level.

Table 8

Mean total errors on serial learning for each stimulus and response similarity condition.

Similarity		Transfer Same	Different	Random	Total
Stimulus	High	20.8	57.5	59.8	47.3
	Low	23.2	83.7	76.1	63.2
Response	High	29.8	90.7	103.0	76.3
	Low	14.2	50.5	42.7	36.9

larity proved to be significant. This interaction, in part, appeared to be due to the small difference in performance between High and Low-R Similarity under the Same condition which, in turn, could be primarily attributed to the superior performance of the Same as compared with the Different and Random groups on the LH list (see Table 6). However, as mentioned previously, the Transfer x List interaction did not prove to be significant.

While overall performance on serial learning was significantly poorer when serial list members were previously paired with Low, rather than with High-S Similarity terms on PA learning (in contrast with the results obtained on PA learning), this High-Low difference (2.4) was negligable under the Same condition. While the latter results are consistent with the previous finding of a greater reduction in errors between High and Low-S Similarity within the C condition on PA learning (see Table 3), the present Transfer x S-Similarity interaction did not prove to be significant. As also shown in Table 8, significantly fewer errors were made under Low than under High-R similarity lists, in agreement with results obtained for this variable on PA learning.

In order to determine the amount of positive and/or negative transfer from PA to serial learning, an analysis was performed on the differences between each S's total serial- and his respective total PA-error score. Table 9

Table 9

Mean difference scores on total errors between paired-associate and serial learning.

Transfer Condition	Lists HH	LL	HL	LH	Total
Same	-57.8	-35.4	-28.4	-40.6	-40.6
Different	-12.4	+ 5.8	+18.4	+46.0	+14.5
Random	-41.2	- 7.8	-77.0	+41.1	-21.3
Total	-37.1	-11.7	-37.0	+18.5	

\- Fewer serial than PA errors.

\+ Fewer PA than serial errors.

shows these mean difference scores for each list under each of the three transfer conditions. As can be seen by looking at the last column in Table 9, the Same transfer condition showed the largest reduction of errors from PA to serial learning. While fewer serial than PA errors also were made by the Random group, the Different group made more PA than serial errors. The analysis of variance performed on these difference scores, which is summarized in Table 10, showed the overall Transfer effect to be significant. Additional comparisons showed that the Same condition differed significantly from the Different condition, F (1,56) = 17.26, whereas the differences between Same and Random and Different and Random conditions did not prove to be significant (F's ≤ 2.47). It can also be seen from Table 9, that direction and/or amount of transfer within each of the three transfer conditions varied across the four lists. Specifically, under the Same condition, a reduction in total serial errors is shown for every list. However, under the Different condition, all lists except the HH list showed an increase in errors on serial learning, indicating negative transfer for the LL, HL, and LH lists under the Different condition. The Random or control condition showed an increase in errors for the LH list, with little difference for the LL list, and substantial positive transfer for lists HL and HH. As shown in Table 10, this interaction of Transfer with Lists proved to be significant. Additional analyses based upon S and R-

Table 10

Analysis of variance summary table for difference scores between PA and serial learning.

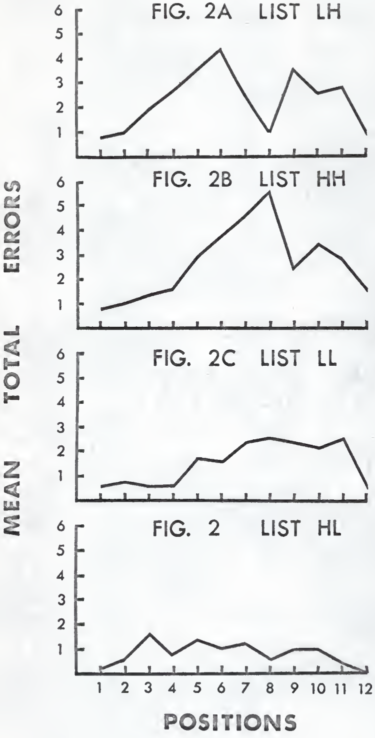
Source	df	Mean Square	*F* Ratio
Total	67		
Groups	11		
Transfer (T)	2	15684.075	8.95*
Lists (L)	3	11743.599	6.70*
S	1	27258.886	15.55*
R	1	4764.890	2.72
S x R	1	3207.020	1.83
T x L	6	5287.177	3.02*
T x S	2	9093.343	5.19*
T x R	2	6722.653	3.84*
T x S x R	2	45.533	<1
Error	56	1752.835	

* Significant at or beyond the .05 level.

Similarity combinations revealed results substantially the same as those based upon the above Lists analysis.

In addition to the above, number of before and after-errors, as shown in Parts II and III of Table 6, were also analyzed. Essentially the same relationships were obtained for these measures as were found with total errors. Of the 11 Ss who failed to reach the two-successive errorless trials criterion on serial learning, one was in the HH-Same group, one in the HH-Different group, one in the HH-Random group, one in the HL-Different group, two in the LH-Different group, and five were in the LH-Random group.

Inspection of the serial position curves for each list under Different and Random conditions showed the typical bowed serial-position curve in each instance. Under the Same condition, some deviations in the shapes of the curves were found to exist among the four lists. Presented in Figures 2A-2D are the mean number of total errors made in each serial position under the Same condition for the LH, HH, LL, and HL lists, respectively. Of particular interest is the serial position curve for the LH list which shows a bimodal error function. Specifically, errors are seen to increase from both ends of the list and then to decrease in positions 7 and 8. These findings, while contrary to results usually obtained in serial learning, are in agreement with the previous finding of a reduction in errors in positions 7 and 8 for the LH list in paired-associate



Figures 2A, 2B, 2C, and 2D. Mean total errors made in each serial position under the Same condition in serial learning for lists LH, HH, LL, and HL respectively.

learning (see p. 25). However, neither the quartic component of the overall Lists x Position interaction ($\underline{F}$ (3,36) = 1.07) nor the quartic component of the LH serial position function alone ($\underline{F} < 1$) reached significance.

DISCUSSION

The results of the present research only partially supported the original intralist similarity hypothesis. The fact that the largest facilitation in paired-associate learning due to constant serial order occurred with high- rather than with low-stimulus similarity lists confirms the notion that high-stimulus intralist similarity is the major factor responsible for constant-varied serial order differences. Furthermore, the finding of significant facilitation under constant as compared with varied serial order for the HL list, along with the finding of no significant facilitation for the LH list confirmed the two specific predictions regarding intralist stimulus and response similarity; namely, that learning under conditions of high stimulus-low response intralist similarity should benefit from constant serial order while conditions of low stimulus-high response intralist similarity should not benefit from constant order pair-presentation. However, the fact that these two list conditions did not produce, respectively, the largest and smallest numerical differences between constant and varied performance was not anticipated, and produced results contrary to initial predictions concerning the role of response similarity in constant serial order paired-associate learning. Specifically, the second largest facilitation due to constant serial order occurred under conditions of high- rather than low-response intralist similarity. Thus, it would appear that as difficulty of paired-associate learning increases, due to the use of high stimulus and/or high response similarity terms, the use of additional cues provided by constant serial order also increases, resulting in an overall facilitation in paired-associate learning. Thus, the HH list revealed the largest and the LL list the smallest difference in performance between constant and varied conditions. The failure to find significant facilitation for the Constant group learning with the LL list was not surprising, since this list parallels the lists used by several previous investigators who also did not find any difference between constant and varied serial order performance (e.g., Martin and Saltz, 1963; Battig et. al., 1963).

That something was learned about the serial order of the response terms even under the LL list condition, is suggested by the serial position curve obtained during paired-associate learning for this as well as the other lists under the constant serial order condition. In this connection, it is interesting to note that significant bowed-shaped functions were found for all but the LH list condition on paired-associate learning, whereas similar results have not been obtained in past research where such analyses have been made (e.g., Battig et. al., 1963). The fact that bowed-shaped functions were found indicates that something was learned about the serial order of the response terms, even where no significant differences in constant-varied performance were observed. Whether these findings reflect position learning, sequential associations among response terms, or more complex processes cannot be ascertained from the present results.

The finding of a significant bimodal function for the constant order LH list on paired-associate learning also suggests that serial cues were being used with this list. The LH list serial position curve revealed fewest errors in beginning, end, and in a restricted portion of the middle of the list. The latter finding of a relative decrease in errors in middle positions is particularly interesting and suggests that Ss learning the LH list may have formed sequential associations among two or three response terms in the middle of the list. The same type of bimodal serial function as found for the LH list in paired-associate learning was also obtained for this list under the Same condition in serial learning. In fact, the reduction of errors in the middle of the list occurred in the same positions (7 and 8), as in paired-associate learning. Thus, it would appear that serial position cues were utilized in the associative process under all list conditions, even though the use of these cues did not serve to facilitate overall paired-associate learning in the LL and LH lists.

Further evidence to support the conclusion that serial position cues were used under all four constant order list conditions was obtained from comparisons among the Same, Different, and Random serial transfer conditions. The fact that the Same group had significantly fewer errors than the Different group, who in turn were insignificantly inferior to the Random group, indicates that a change in the serial order of the response terms from paired-associate learning results in interference in serial learning. It is also interesting to note that the Same condition showed significant positive transfer from paired-associate learning on all lists, whereas the Different condition showed relative negative transfer on all but the HH list. In fact, the Different condition made more total errors on serial learning relative to paired-associate learning than did the Random condition. The fact that the HH list showed positive and not negative transfer under the Different condition may be explicable in terms of response familiarization. Specifically, under the present Different transfer condition both negative and positive transfer effects are possible. While negative transfer is expected due to a change in the serial order of the response terms, prior response-term familiarization during paired-associate learning may be expected to produce a positive transfer effect. Thus in the case of the HH list under the Different transfer condition, it would appear that the beneficial effects of prior response familiarization served to counteract any negative transfer accruing from the change in serial order of the response terms in serial learning.

The above explanation can also account for overall negative transfer with the two low-response similarity lists (LL and HL) by a reduced positive transfer effect from prior response familiarization. However, the fact that the LH list showed substantial overall negative transfer under the Different condition, seems, at the surface, inconsistent with the above response familiarization explanation. At present, no further or alternative explanation for these discrepant findings can be offered. The fact that the LH list also displayed substantial negative transfer under the Random serial condition is even more puzzling since only positive transfer due to prior familiarization of the response terms should be expected (i.e., no negative transfer was anticipated since Ss under this condition did not learn the response terms in a constant serial order on paired-associate learning). Whether this result was due to the particular combination of stimulus and response similarity used in this list or to some other factor(s) cannot be ascertained at the present time.

The present study, as well as previous research in the area, has been primarily concerned with the question of whether or not actual serial learning of response terms occurs under constant serial order paired-associate learning. It would also be interesting to determine whether constant serial order also serves to strengthen associative connections between the stimulus and response members of a pair. By transfering constant order paired-associate subjects to another paired-associate list, with stimulus terms in a different order but response terms in the same order as in original paired-associate learning, it would be possible to evaluate the extent and magnitude of such stimulus-response learning in different serial positions of the list.

In conclusion, while the results of the present research show that constant serial order facilitates paired-associate learning primarily under conditions of high stimulus and high response intralist similarity, still little is known about the specific mechanism(s) responsible for this facilitation. Nevertheless, the present study has attempted to discover and quantify functional relationships between intralist similarity and presentation order of paired-associates. Perhaps the most important contribution of the present research has been to demonstrate that while there are certain conditions under which paired-associate learning is facilitated with constant serial order, this does not necessarily mean that serial cues are not being utilized under conditions where this facilitation does not manifest itself. Future research and theorization in the area should profit by orienting itself to these findings.

REFERENCES

Archer, E. J. A re-evaluation of the meaningfulness of all possible CVC trigrams. Psychol. Monogr., 1960, 74, No. 497.

Battig, W. F., & Brackett, H. R. Comparison of anticipation and recall methods in paired-associate learning. Psychol. Rep., 1961, 9, 59-65.

Battig, W. F., Brown, S. C., & Nelson, D. Constant vs varied serial order in paired-associate learning. Psychol. Rep., 1963, 12, 695-721.

Brown, S. C. Interpair interference as a function of level of practice in paired-associate learning. J. exp. Psychol., 1964, 67, 316-323.

Brown, S. C., & Battig, W. F. Partial serial position constancy in paired-associate learning. J. verbal learning and verbal behavior, 1962, 1, 42-47.

Deese, J. The psychology of learning. (2nd ed.) New York: McGraw-Hill, 1958.

Grant, D. A. Analysis-of-variance tests in the analysis and comparison of curves. Psychol. Bull., 1956, 53, 141-154.

Martin, C.J., & Saltz, E. Serial versus random presentation of paired-associates. J. exp. Psychol., 1963, 65, 609-615.

McCrary, J. W. Jr., & Hunter, W.S. Serial position curves in verbal learning. Science, 1953, 117, 131-134.

McGeoch, J. A., & Irion, A.L. The psychology of human learning. (2nd ed.) New York: Longmans, Green & Co., 1952.

McGeoch, J. A., & McKinney, F. Studies in retroactive inhibition: VIII. The influence of relative order of presentation on original and interpolated paired associates. J. exp. Psychol., 1937, 20, 60-83.

McGeoch, J. A., & Underwood, B. J. Tests of the two-factor theory of retroactive inhibition. J. exp. Psychol., 1943, 32, 1-16.

Newman, S. E. Serial position as a cue in learning: The effect of test rate. J. exp. Psychol., 1965, 70, (in press) (a).

Newman, S. E. Effects of serial presentation of paired-associates on performance. Paper read at Southeast. Psychol. Ass., Atlanta, April, 1965 (b).

Newman, S.E., & Saltz, E. Serial position as a cue in learning. _Amer. J. Psychol._, 1962, _75_, 102-108.

Underwood, B. J. Stimulus selection in verbal learning. In Cofer, C. N., & Musgrave, Barbara S. (Eds.) _Verbal behavior and learning: problems and processes_. New York: McGraw-Hill. 1963.

APPENDIX 1

PAIRED-ASSOCIATE INSTRUCTIONS

This is an experiment in what we call paired-associate learning. The experimental session will be from one to two hours long and you will earn one or two hours experimental credit depending on the amount of time that you participate.

On the first trial, you will be shown, on the screen before you, 12 pairs of nonsense syllables (a nonsense syllable is a three letter combination which does not make a word in the English language). Your task is to study each of these and to learn to associate both of the syllables together. After all 12 pairs have been presented, you will be shown, one by one, just the left-hand syllable of each pair. You are to try to respond by spelling the right-hand syllable which had been previously paired with it. This constitutes one trial and the following trials will be the same.

Thus, first you will see a series of 12 slides with nonsense syllable pairs, from which you form associations. The slides are then presented again with only the left-hand syllables exposed. To each of these you are to respond with the right-hand syllable which makes up that particular pair.

Each slide will be presented for four seconds. In addition, there will be a short rest interval following each presentation of the 12 slides.

(Example given here)

To summarize, each learning trial consists of two series of presentations; the first with both nonsense syllables exposed and the second with only the left-hand syllable exposed. Do not hesitate to guess if you are not sure of the correct response. Are there any questions?

SERIAL-LEARNING INSTRUCTIONS

Your next task will involve what we call serial learning. This procedure is different from before in that you are to learn a list of 12 single nonsense syllables, each presented one at a time, with the syllables being in the same order on every trial. Your task is to learn the order in which the syllables appear, by attempting to anticipate each syllable before it actually appears on the screen. The list will be preceded by an asterisk and when you see the asterisk, you are to try to anticipate the first syllable in the list by spelling it aloud. Then, when you see the first syllable, try to spell the second syllable before it appears on the screen, and so forth until you have reached the end of the list. This constitutes one trial.

Each slide will be presented for four seconds and there will be a short rest interval between trials.

(Example given here)

Are there any questions?

I should point out that the syllables to be used in the present serial learning task are the same as the 12 response or right-hand syllables used previously in the paired-associate task. Since you are already familiar with these syllables, please feel free to guess if you think you know where a syllable will appear in the list, even on the first trial. Do not hesitate to guess if you are not sure of the following syllable.

To summarize, each trial consists of the presentation of an asterisk followed by the 12 syllables. You are to try anticipate each syllable by spelling it before it actually appears on the screen. Are there any questions?

APPENDIX 2

Listing of the paired-associate lists used in Part I. Also presented are the mean pair association-values for each pair.

High-High Similarity H_1 H_2	Mean Pair Association-value	Low-Low Similarity L_1 L_2	Mean Pair Association-value
1. LUW - VAC	60.0	1. CAY - MIJ	55.5
2. MOF - VIK	57.0	2. KAS - DOY	53.0
3. MUW - CIV	59.5	3. TIR - PUQ	54.5
4. FOW - CAK	58.5	4. YUK - JOW	53.0
5. LUF - KAV	57.0	5. VOG - SEB	56.5
6. WOL - ZAC	60.0	6. JEB - QAD	56.5
7. FOL - KIZ	56.5	7. REQ - NAL	60.0
8. LOM - KAC	56.5	8. NUZ - TIX	57.0
9. FUM - VIZ	54.5	9. SAH - BIP	60.5
10. WUF - CIZ	53.0	10. HIV - GER	64.5
11. WOM - ZIV	53.0	11. PEX - WUF	53.5
12. MUL - ZAK	55.5	12. GOC - FEN	56.5
Total Mean	56.75	Total Mean	56.75

High-Low Similarity	Mean Pair Association-value	Low-High Similarity	Mean Pair Association-value
H_1 L_1		L_2 H_2	
1. LUW - CAY	56.5	1. MIJ - VAC	59.0
2. MOF - KAS	53.5	2. DOY - VIK	56.5
3. MUW - TIR	57.5	3. JOW - CAK	53.5
4. FOW - YUK	58.5	4. PUQ - KAV	53.0
5. LUF - VOG	52.5	5. QAD - CIV	59.5
6. WOL - NUZ	63.0	6. SEB - ZAC	52.5
7. WOM - JEB	66.0	7. NAL - KIZ	52.5
8. LOM - REQ	64.0	8. TIX - KAC	56.0
9. FUM - SAH	53.5	9. WUF - VIZ	54.5
10. FOL - HIV	56.5	10. FEN - CIZ	56.5
11. WUF - PEX	53.5	11. GER - ZIV	58.0
12. MUL - GOC	56.5	12. BIP - ZAK	54.0
Total Mean	57.63	Total Mean	55.41

CONSTANT VERSUS VARIED SERIAL ORDER IN PAIRED-ASSOCIATE LEARNING AS A FUNCTION OF INTRALIST SIMILARITY

by

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Research in verbal learning has traditionally maintained a sharp distinction between serial learning, where the subject is required to learn a series of items in a particular sequence, and paired-associate (PA) learning, where the subject is required to learn several different pairs of items in a manner which will enable him to recall the correct response member when shown the stimulus member of each pair. In line with this distinction, PA procedures usually vary the order of presentation from trial to trial as a means of avoiding facilitation through the actual serial learning of the pairs in order. However, results of recent research seriously question the generality of such serial facilitation and point to the need for more systematic formulation and specification of the conditions under which constant serial order facilitates PA learning. The purpose of the present study is to offer one such formulation, based upon variations in intralist stimulus and response similarity, which not only allows for partial systematization of the results of previous research, but also empirical tests of specific predictions generated from this formulation. Specifically, it was hypothesized that conditions of high-intralist stimulus similarity, by increasing the difficulty of forming stimulus-response associations within pairs, should lead to the serial learning of response terms under the constant serial order procedure. However, under conditions of high-intralist response similarity, learning of response terms in serial order should be discouraged due to the difficulty of forming these sequential associations.

In order to test the above intralist similarity hypothesis, each of 80 subjects (_S_s) learned a 12-pair list of nonsense syllables under conditions of either _Constant_ or _Varied_ serial order. In addition, one-quarter of the _S_s (10) within each condition learned each of four different lists. These lists differed from one another in terms of variation in _high_ and _low_ _stimulus_ (S) and _response_ (R) intralist similarity, and constituted the low S-low R, high S-high R, low S-high R, and high S-low R similarity lists. After completion of PA learning, all _S_s learned a serial list consisting of the 12-response terms used in PA learning. For this purpose the Constant group was subdivided into two groups. For _S_s in the _Same_ group, these response terms appeared in the same order as in PA learning, whereas for _S_s in the _Different_ group the 12-response terms appeared in an order different from that used in PA learning. Each _S_ in the Varied condition also learned a serial list comprised of the 12-response terms which they studied during PA training.

The results only partially supported the original hypothesis. The largest facilitation in paired-associate learning due to constant serial order occurred under conditions of high-intralist stimulus similarity, thereby confirming the notion that stimulus similarity is the major factor responsible for differences in constant-varied serial order performance. However, the second largest facilitation was found under conditions of high rather than low-response intralist similarity, contrary to the original hypothesis. Furthermore, the finding of significant differences in difficulty of learning across serial positions under the constant condition for all lists in PA learning, along with substantial negative transfer under the Different relative to the Same condition on serial learning, strongly suggests that something was learned about the serial order of the response terms under all four list conditions.

While several explanations for the obtained results were offered, the most significant contribution of the present research was to demonstrate the utilization of serial cues in the associative process even under conditions where such cues do not serve to facilitate paired-associate learning.