INTRALIST CATEGORIZATION: THE EFFECT OF ADDING A SECOND STIMULUS TO SUBSETS OF PAIRED ASSOCIATES

by

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The typical paired-associate (PA) learning task consists of successive presentations of a list of several stimulus-response pairs, in varied order from trial to trial, until a predetermined criterion of performance is reached. In such a task, learning of the pairs occurs through the association of each response member in the list with its corresponding stimulus term. It has recently been demonstrated, however, (e.g., Underwood, 1963) that the stimulus term presented to the subject may not be isomorphic to the element he uses in forming the association with the response term. In other words, it is necessary to distinguish the nominal stimulus, that which the experimenter designates as the unit to which a response is to be associated, from the functional stimulus, the unit actually used by the subject in the associative process, which may or may not be identical to the nominal stimulus. In this connection, several recent investigations concerned with stimulus selection processes in PA learning have attempted to ascertain which unit or units of the stimulus configuration the subject attends to in learning. The purpose of the present paper is to review the results of some of these experiments and to present additional empirical information about the role of stimulus cues in PA learning.

To determine what constitutes the functional stimulus in learning, the subject is presented with at least two stimulus elements (e.g., a word and a nonsense syllable). The subject may, therefore, form an association between either or both of these stimulus elements and the corresponding response term. The problem in stimulus selection experiments is to specify those variables which influence the stimulus selection process. Typically, subjects first learn a list of paired associates with all stimulus elements present. Then they are tested for response recall with each stimulus element separately to determine their relative associative strength.

Elements which have been commonly used as members of compound stimuli in previous studies include words (Sundland & Wickens, 1962), numerals (Birnbaum, 1966), nonsense syllables (Cohen & Musgrave, 1964), colors (Weiss & Margolius, 1954), and single letters (Postman & Greenbloom, 1967). Studies using two or more verbal units (e.g., words and/or nonsense syllables) are of primary interest for the present study. Spear, Ekstrand, and Underwood (1964) combined low-meaningful units (words) to form compound stimuli. These investigators found nearly perfect response recall after learning to the high-meaningful unit; that is, omission of the nonsense syllable had little effect on recall. However, they also found that the nonsense syllable had some functional properties, since presentation of this cue alone produced a significant number of correct responses. Subjects, therefore, showed familiarity with both stimulus units, although the high-meaningful item was selected as the functional stimulus significantly more often than the low-meaningful nonsense syllable. James and Greeno (1967) and Cohen and Musgrave (1964) also found that the stimulus element of higher meaningfulness led to consistently better recall. From these studies, it would appear that relative meaningfulness of the two stimulus units is an important factor influencing stimulus selection processes in verbal learning.

The studies cited above have been concerned with specification of the functional stimulus in PA learning: the more meaningful unit is selected more often than the less meaningful unit as the functional stimulus. Previous investigations using compound stimuli also have been concerned with a second question: namely, does learning of the pairs proceed faster when each response is paired with one or two stimulus units. When the compound stimulus consists of two high-meaningful units, a decrement in learning has been reported (Horowitz, Lippman, Norman, & McConkie, 1964; Musgrave & Cohen, 1964). Likewise, learning is retarded with two low-meaningful units (Cohen & Musgrave,

1964). When the units of the compound stimulus differ in meaningfulness, the results are less clear. Examination of the data presented by Cohen and Musgrave (1964) indicates a decrement from adding a low-meaningful unit to a high-meaningful unit. Thus, the addition to the list of a more difficult second stimulus retards learning. However, when the added stimulus term is more meaningful than the single stimulus, the Cohen and Musgrave data show little or no decrement in learning and even a slight facilitation when the more meaningful unit appeared consistently to the left of the less-meaningful unit. Thus, relative meaningfulness of stimulus units appears to influence both PA performance and stimulus selection processes.

Because of the primary concern of previous studies with stimulus selection processes, these have necessarily used compound stimuli whose elements appear only once in the list; i.e., no stimulus unit is repeated. Under such conditions of no stimulus overlap either element alone can serve as the functional stimulus. A broader application, however, of the technique lies in its potential usefulness for the study of organizational processes in PA learning. If one of the stimulus units of the compound is shared by more than one pair in the list, this unit can no longer function as a completely effective stimulus. However, under these conditions, it may be used by the subject to classify pairs into subsets, providing organization to the list. One result of this classification may be to reduce intralist interference. Specifically, associations among items within a subset may reduce interference (e.g., response competition) from items outside the subset. At the same time, however, the formation of subsets of pairs in the list may cause interference among items contained within a given subset as a result of increased similarity among items sharing the same subset cue (e.g., Postman & Phillips, 1964). In an attempt to gain information about the effect of

stimulus sharing, earlier research by Brown and Sanford (1968) added four high-meaningful words to a 16-item PA list composed of low-meaningful stimuli. Each word appeared with a subset of four different stimulus-response pairs. All subjects practiced the list for 15 trials. Poorer performance was obtained with than without subset cues in the list. Moreover, most of the decrement was due to an increase in the number of intralist errors which were responses from pairs in the same subset as the correct response. Thus, subjects attended to the more meaningful subset cues, even though learning was thereby retarded.

The previous study established that a decrement in PA learning is produced from adding subset cues to the list. However, because the earlier research of Brown and Sanford (1968) did not systematically vary number of subset cues, the results may be peculiar to the particular number of cues selected for study. That the addition of high-meaningful units to the list may produce a facilitation in learning is suggested by the Cohen and Musgrave (1964) data cited above, and by other research which has presented stimulus terms on differently colored backgrounds (e.g., Weiss & Margolius, 1954). Thus, previous studies suggest that the decrement in PA performance from adding a second cue will be limited to conditions where the added cue is shared by more than one response term. However, it cannot be ascertained from the previous data whether the relationship between PA performance and number of added cues is a continuous or discontinuous function, i.e., whether the shift to relative facilitation from adding a second cue occurs prior to conditions of nonoverlap of stimulus units. The major purpose of the present study is to determine the nature of the above relationship.

Because of previous demonstrations of a greater utilization in learning of the more meaningful stimulus unit (e.g., Cohen & Musgrave, 1964), it was anticipated that the relative meaningfulness of subset cues would also affect

learning in the present study. Consequently, relative meaningfulness of PA stimuli and subset cues was also included as a variable in the present study. Finally, a recall test was administered after PA learning to determine the relative associative strength between PA responses and subset cues.

Method

Subjects

The subjects (Ss) were 152 paid college students enrolled in summer school at Kansas State University. Each S served for a single session of one hour or less.

Paired-Associate (PA) Learning

Conditions.--The Ss were divided into nine groups. Each group learned a list of 16 paired associates to a criterion of one errorless trial using the pairing-test (recall) method (Battig & Brackett, 1961). The groups differed with respect to (a) number of additional cues in the list (either 0, 2, 4, 8, or 16), and (b) meaningfulness of added cues (low and high). With 2, 4, and 8 cues added, subsets of pairs were created, since each of these cues appeared with more than one response term. With 16 cues added, either set of stimuli could serve as functional stimuli, and no subsets were present in the list. Thus, the 16 condition represented a nonoverlapping compound stimulus condition, typically employed in previous research. Low-meaningful items were low association value CVCs, while high-meaningful items were familiar nouns. With 2, 4, and 8 subset cues present (Cond 2, 4, and 8, respectively), each cue appeared with 8, 4, and 2 different pairs in the list, respectively. The type of verbal material (nouns or CVCs) not used as PA stimuli constituted the subset cues, and vice versa. Under Cond 0, two different groups of Ss

learned the 16 pairs without subset cues, one with word and the other with CVC-stimuli alone. Thus, excluding Cond 16, the design constituted a 2 X 4 factorial with noun- vs CVC-stimuli as one variable and number of subset cues as the second variable. Sixteen Ss served under each condition, except in Cond 16, where n = 24.

Procedure.--The Ss were assigned to the nine groups according to a prearranged order which assured that the groups were filled at the same rate. Upon entering the experimental room, each S was seated in front of a plywood screen which shielded him from E and the apparatus. Typical instructions for PA learning were given (see Appendix 1), but no mention of the rules for combining subset cues with pairs was made. After E was assured that S understood the task, learning trials began. Each trial consisted first of the presentation of all 16 members of the list, followed by a recall series in which only the PA stimulus (and subset cue) of each pair was exposed. The S attempted to pronounce the correct response of each pair. The 16 cards containing the members of the list, together with a "ready" card put on top of the deck, were placed by E in a tray located in an aperture at the base of the plywood screen. The E exposed each card in the deck for 3 sec. An audible click from an electrically operated repeat-cycle timer was used to pace presentation. Forty-five sec. elapsed between trials and between pairing and test series within trials. During these intervals E shuffled the cards for the next presentation of the deck.

Two different Es each ran half the Ss in each condition. Analysis of variance showed a significant overall difference between Es, but the effect was not differential across conditions, as evidenced by the failure to find significant interactions involving Es and conditions (p's $> .20$). Consequently, these interactions have been pooled in the error term for all analyses to be reported.

Materials.--The 16 low-meaningful stimuli and subset cues were 14-31% Archer (1960) association value CVCs, with a mean value of 23.1%. Formal similarity (i.e., letter duplication) among items was kept minimal by selecting CVCs with no initial letters repeated, no final letters repeated, and vowels distributed approximately equally over the 16 items. High-meaningful stimuli and subset cues were all 4- and 5-letter familiar nouns. Each noun had a different initial letter, and all were rated AA in the Thorndike-Lorge (1944) word frequency count. The responses for all lists were 6-8-letter occupation names, each beginning with a different initial letter. An attempt was made to select occupations which were not similar in meaning. The members of the list were typed on individual 3 X 5 in. index cards. The PA stimuli and subset cues were presented on both pairing and test series of each trial and were typed side by side on the left half of the card. To control for possible positional effects (Cohen & Musgrave, 1964), half the cards on each trial presented PA stimuli to the left and half to the right of the subset cues. Left-right positions of individual items were alternated from trial to trial. For pairing and test series within a given trial, however, individual items appeared in the same relative position.

The 16 stimulus-response pairs were identical in all conditions in which PA stimuli consisted of the same type of verbal material (i.e., nouns or CVCs). Subset cues were added to pairs in a manner that yielded, in most cases, groups of identical subset cue-pair combinations across lists. This was accomplished by using two of the subset cue-pairs from Cond 2 as two of the combinations in Cond 4, 8, and 16. Likewise, four of the combinations in Cond 4 were also used in Cond 8 and 16. A similar procedure was followed in constructing the list for Cond 16. Appendix 2 presents each list separately. In constructing the subsets, care was taken to avoid pairing items with obvious associations between subset cues and PA stimuli and between either of these and responses.

Recall

Conditions and procedures.--Five min. after completion of PA learning, Ss in each condition were divided into subgroups by each E on the basis that number of Ss (8), total trials, and variability of scores be matched for each subgroup. This produced two matched subgroups under Cond 0, 2, 4, and 8 and three under Cond 16. The subgroups were then required to recall the 16 responses of the PA list under each of the following conditions:

1. Free Recall (FR). The Ss were given a blank sheet of paper and instructed to write down the responses without any stimulus cues present.

2. Subset-Cued Recall (CR). The Ss were given a sheet of paper containing the subset cues from the PA list and instructed to write down the responses and to pair each with the subset cue it had appeared with in the PA list. The Ss were told to guess as to subset identification if they could remember the response but were unsure of its pairing.

3. Stimulus-Cued Recall (SR). The Ss were given a sheet of paper containing the 16 PA stimuli of the list. They were instructed to write down the responses and to pair them with their correct stimuli. Again, Ss were told to guess if they could remember a response but were unsure of its pairing.

The two recall subgroups under Cond 2, 4, and 8 received the FR and CR conditions, respectively. In each of the two 0 conditions, one subgroup was tested under the FR and the other under the SR condition. In Cond 16, one subgroup received FR, a second SR with CVCs present, and the third SR with nouns present.

During the five min. interval between PA learning and retention, Ss were given a number deletion task to minimize rehearsal of the list. Each S was presented with sheets of paper containing 250 two-digit numbers and instructed

to cross out all even numbers as rapidly as possible. Prior to the retention test, Ss were not told that they would be required to recall the responses. Four min. was allowed for completion of the retention test. Appendix 3 contains the recall instructions.

Results

Paired-Associate Learning

Overall Performance

Table I presents the mean number of total PA errors and standard deviations, separately for each experimental condition. Except for virtually identical performance under the 2- and 4-noun-subset conditions, there was an increase in number of errors with an increase in both number of noun and CVC subset cues from 0 through 8, followed by a decrease with nonoverlapping compound stimuli (Cond 16). Cond 16 produced faster learning than any noun-subset condition but was superior only to Cond 8 when CVCs served as subset cues. Analysis of variance, excluding data from Cond 16, showed both the overall effect of number of subset cues (0-8) and the substantially faster learning with PA noun stimuli (CVC-subset cues) than PA CVC stimuli (noun-subset cues) significant, F (3,112) = 4.65 and F (1,112) = 64.38, respectively. (Except where indicated, $p < .05$.) The interaction between number of subset cues (0,2,4, and 8) and type of cue fell far short of significant ($F < 1$).

To provide a more descriptive and sensitive statistical test of the relationship between performance and number of subset cues, extended trend analysis of variance (Grant, 1956) was performed separately for noun- and CVC-subset conditions. For this purpose, it was assumed that intervals between Cond 0 and 2, 2 and 4, and 4 and 8 were of equal magnitude. The results showed the linear component of the variation across Cond 0 through 8 significant both

TABLE I. Mean number of total errors, trials to criterion and standard deviations (σ) in PA learning.

		NUMBER OF ADDED CUES				
Type of Cue		0	2	4	8	16[1]
Noun	$\bar{X}$	41.8	56.1	55.6	70.8	26.0
	σ_x	28.2	29.5	25.8	24.6	18.5
	Trials	7.8	9.8	9.3	10.8	5.5
	σ_t	5.3	4.5	3.8	3.0	3.2
CVC	$\bar{X}$	16.8	20.5	23.1	31.3	26.0
	σ_x	15.9	17.8	9.4	28.5	18.5
	Trials	4.3	4.6	5.1	5.7	5.5
	σ_t	3.1	2.8	2.2	3.2	3.2

1. Cond 16 scores are presented twice, since these scores provide a logical terminating point for both types of added cues.

for noun and CVC subset conditions, Fs (1,59) = 8.69 and 4.68, respectively. All other orthogonal components were nonsignificant, as were all components of the Type X Number of subset cue interaction (p's .20). Thus, the PA results fail to indicate a significant differential effect from noun- than CVC-subset cues, contrary to original expectation. Also of interest is direct comparison of Cond 0 and Cond 16, which revealed a significant facilitation in learning when a noun was added to a CVC to form a compound stimulus, F (1,37) = 5.03. The decrement produced by adding a CVC to a noun was not significant, however, F (1,37) = 2.77, p .10.

Table I also presents the mean number of trials to ceiterior for each condition. Inspection of these data again showed poorer performance with an increase in number of noun- and CVC-subset cues. Analysis of variance based upon the trials data revealed results essentially the same as those obtained using total errors, except that the decrement from adding CVC subset cues was not significant (F 1).

Types of Errors

Extraneous, Intralist and Omission Errors.--To help specify the source of interference under the various conditions, detailed analyses were performed on the types of errors committed during learning. Ss could commit three main types of errors: errors of substitution of responses which were not present in the list (extraneous errors), errors of substitution of responses which were in the list (intralist errors), and failures to respond (omission errors). Since the number of extraneous errors was negligible and virtually the same under all conditions, these will not be presented separately. The mean number of total errors (including extraneous errors), omission errors, and intralist errors under noun- and CVC-subset conditions are shown separately in Fig. 1. The increase in total errors from Cond 0 to Cond 2 with noun subset cues consists

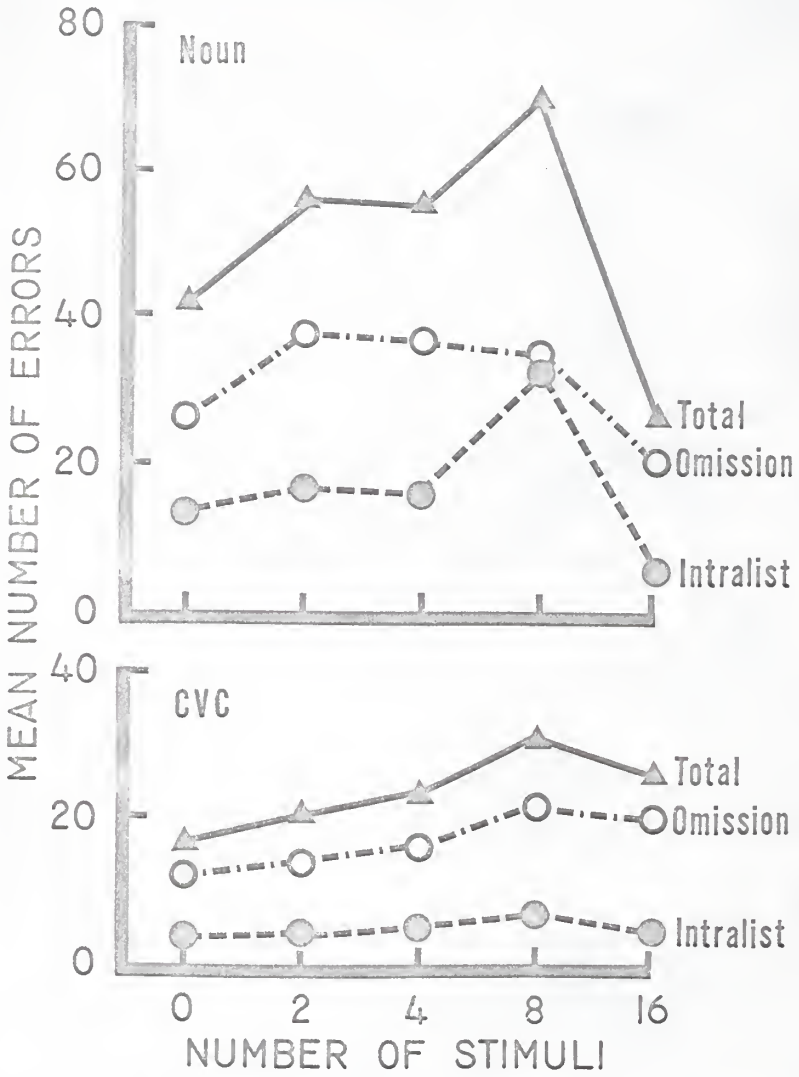

Fig. 1. Mean number of total, omission, and intralist errors with noun and CVC subset cues.

largely of omission errors, although the difference between the two conditions fell short of significance, F (1, 29) = 2.25, $p > .10$. The further increase in total errors from Cond 4 to Cond 8 is due entirely to an increase in intralist errors, leading to a significant difference between the two conditions, F (1, 29) = 11.42. With CVC subset cues, both omission and intralist errors increase as more cues are added to the list. With omission errors, the linear component of the trend barely failed to reach significance, F (1, 59) = 3.82, $.05 < p < .10$, whereas the linear increase of intralist errors was significant, F (1, 59) = 4.03.

To gain additional information about the effects of subset cues, intralist errors were further broken down into two categories: responses from pairs sharing the same subset cue as the correct response (within-errors) and responses from pairs categorized under a different cue (between-errors). It is important to note that there are fewer opportunities for Ss to commit within-errors and, conversely, more opportunitites to commit between-errors as number of subset cues in the list increases from 2 to 8. This occurs because fewer pairs appear with each subset cue. Thus, as more cues are added, an increase in the absolute number of between-errors and a corresponding decrease in number of within-errors would be expected by chance. To equate for the differential opportunity, Expected within- and between-error scores were obtained from the two 0 conditions by grouping pairs into subsets as if subset cues had been present in the list, and then calculating the frequency of the two types of errors within each subset of pairs. It was felt that chance expectancy established in this way was more accurate measure than a similar measure computed from statistical probability because it was based on the actual verbal materials used. All statistical analyses treated data from the control group as a Between S source of variance. Fig. 2 shows the difference between Expected and Actual within- and between- errors under both noun and CVC 2, 4, and 8 subset conditions. For

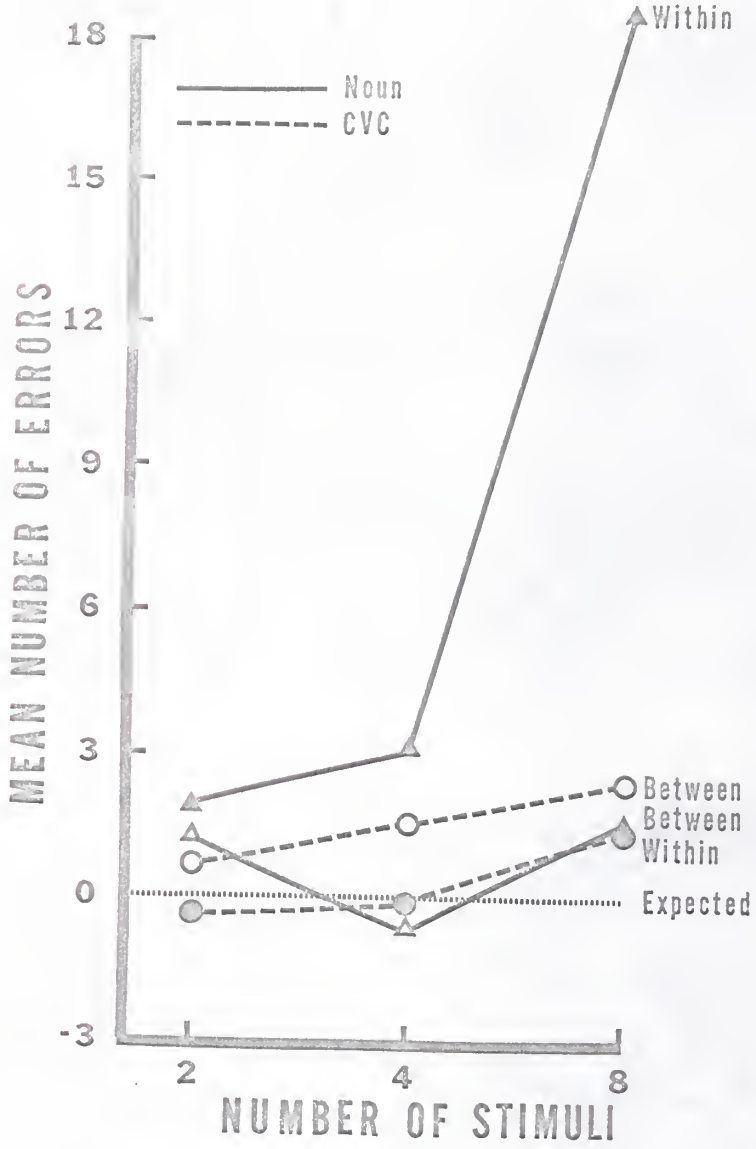

Fig. 2. Mean diff. between Actual and Expected within- and between-errors with noun and CVC-subset cues.

noun-subset groups, the number of within errors increased relative to Expected errors while between-errors showed considerably less and unsystematic change across 2, 4, and 8 conditions. Thus, there seems little doubt that the decrement in performance under the 8 noun-subset condition is due almost entirely to within-errors. For CVC-subset conditions, there was a relative increase in both within- and between-errors. The increase in within-errors with noun subset cues was significant, F (2,84) = 13.67, as was the overall difference between Actual within-and Expected within-error scores, F (1,84) = 30.20. However, between-error scores with noun subset cues and within- and between-errors with CVC cues failed to reveal either an overall significant difference from Expected or significant changes across Cond 2, 4, and 8 (p's > .05).

Stages of Learning.--Despite the failure to find significant increases in between errors under CVC-subset conditions, it was felt that these CVCs may have caused confusion among items in different subsets. If this were the case, it seems reasonable that this confusion should be manifested early in learning when discrimination among CVCs is presumably minimal. Therefore, each S's learning trials were divided into four stages, each representing one fourth of his total trials to criterion. The mean number of Actual and Expected between-errors for 2, 4, and 8 CVC-subset conditions are shown in Fig. 3. It can be seen that a large portion of the difference between Actual and Expected between-errors under each condition is restricted to the first two quarters of learning. By the third and fourth quarters, the differences are very slight and, in 2 and 4 conditions, in the direction of more Expected than Actual between-errors. Moreover, the difference in performance proved reliable, as evidenced by a significant interaction between Stages and Expected-Actual

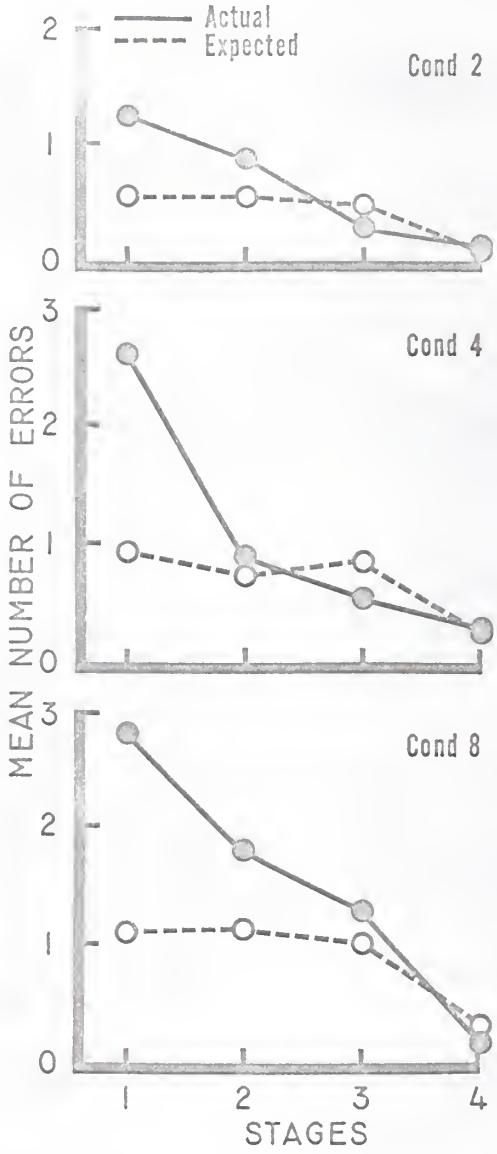

Fig. 3. Mean number of Actual and Expected between-errors across 4 stages of learning in CVC-Subset Cond 2, 4, and 8.

between-errors, F (3,270) = 11.05. The Stages X Expected-Actual X Number of Subset Cues interaction fell far short of significance, F (6, 270) = 1.17, $p > .20$. Thus these data provide support for the notion of increased confusion early in learning among subsets with CVC cues. Within-error data obtained in the same way was very irregular, perhaps due to the paucity of this type of error throughout learning. Likewise, inspection of noun subset data divided into quarters showed little differential change in either within- or between-errors across stages of learning. The only exception to this was Cond 8 which showed a relative increase in within-errors in the second quarter of learning.

Retention

Table II shows the mean number of responses recalled correctly in each retention condition. SR (Stimulus-Cued Recall) and CR (Subset-Cued Recall) scores have been subdivided for two types of analysis: (a) mean number of total responses recalled, regardless of whether these were paired with correct stimuli or subset cues (SR_T and CR_T, respectively); and (b) mean number of responses paired with their correct stimuli or subset cues (SR_P and CR_P, respectively). Of particular interest is comparison of CR_P scores across the various experimental conditions. As shown in Table II, fewer responses were paired with correct CVC subset cues as the number increased from 2-8. However, the opposite result was found for noun cues. Analysis of variance across both types of cue conditions showed a significant overall difference in recall between types of subset cues, F (1,41) = 33.55, as well as a significant Type X Number of Subset Cue interaction, F (2,41) = 16.71. Thus, significantly more responses were paired with noun than CVC subset cues and the difference increased as more cues were added to the list.

It should be noted that as number of subset cues increases, the statistical probability of any response being paired by chance with its

Table II. Mean Recall Scores

Type of Cue		Number of Added Cues				
		0	2	4	8	16[1]
Noun	FR	14.5	14.9	15.3	15.8	13.8
	CR_T		13.9	14.1	15.8	
	CR_P		8.5	10.6	15.8	
	$\%CR_P(Ac)$		61.1	75.2	100.0	
	$\%CR_P(Ex)$		50.0	25.0	12.5	
	%Diff		11.1	50.2	87.5	
	SR_T	16.0				15.9
	SR_P	16.0				15.9[2]
CVC	FR	13.9	13.1	13.5	12.4	13.8
	CR_T		13.0	13.4	12.8	
	CR_P		8.8	4.9	4.1	
	$\%CR_P(Ac)$		67.4	37.1	31.0	
	$\%CR_P(Ex)$		50.0	25.0	12.5	
	%Diff		17.4	12.1	18.5	
	SR_T	16.0				12.6
	SR_P	16.0				3.1[3]

1. CVC and noun FR scores in Cond 16 represent the same data.
2. Nouns presented as SR stimuli.
3. CVCs presented as SR stimuli.

correct subset cue decreases, i.e., the number of responses paired with each cue decreases. Table II shows the Actual and Expected percent CR_p scores. It can be seen that the absolute decrease in correct CR_p as CVC subset cues are added nearly parallels the decrease in chance expectancy, although the scores are higher than chance in each condition. The decrease in Expected percent CR_p also serves to emphasize the absolute increase in these scores as noun subset cues are added. With both noun and CVC subset cues, percent CR_p was significantly higher than scores expected by chance, both $\underline{F}$s >16.00. The increasing difference from chance across noun subset conditions was likewise significant, $\underline{F}$ $(2,21) > 100$, but the difference between CVC subset conditions and chance did not vary significantly across conditions ($\underline{F} < 1.00$). It seems, then, that $\underline{S}$s paired responses with both noun and CVC subset cues to a greater extent than expected by chance. While the difference increased as more nouns were added, no increase was obtained with CVC cues.

Table II also shows the mean number of correct responses in free recall (FR). As shown, noun-subset groups overall recalled responses consistently better (Mean = 15.1) than CVC groups (Mean = 13.2). This difference was significant, $\underline{F}$ $(1,56) = 33.68$. There was also a significant increase in FR correct responses from Cond 0-8 with noun cues, $\underline{F}$ $(3,27) = 3.49$, but not with CVC cues, $\underline{F}$ $(3,27) = 1.21$, $\underline{p} > .25$, leading also to a significant Type X Number of subset cue (0-8) interaction, $\underline{F}$ $(3,56) = 3.07$. It can thus be concluded that subset cues noun produced better FR than CVC cues and that the difference increased in magnitude as more nouns were added to the list.

Other findings of interest include (a) a significant difference in Cond 16 in the number of responses paired correctly with the noun (15.9) as compared with the CVC (3.1) component of the compound stimuli, $\underline{F}$ $(1,14) = 198.85$;

(b) no significant difference in FR between the 0-CVC PA stimulus condition and the 16 condition, F (1, 14) = 1.35, $p > .25$; (c) no significant difference in FR between the 0-noun PA stimulus condition and the 16 condition, ($F < 1.00$); and (d) significantly better overall CR_T with noun (14.6) than with CVC subset cues, (13.1) F (1,42) = 15.67.

Discussion

One of the primary aims of the present study was to examine the effects of adding subset cues to a PA list. It was found that the presence of these cues significantly retarded PA performance, replicating the results of the earlier research (Brown & Sanford, 1968). Furthermore, the present investigation showed that the decrement increased as more cues were added until either stimulus term of the compound could act as the functional stimulus (Cond 16).

It had been expected that effects due to stimulus sharing would be attenuated when the subset cues were less meaningful than the PA stimuli. However, both noun and CVC subset cue conditions showed a nearly comparable increase in number of errors as these cues were added to the list. Likewise, the lack of significant interactions between type and number of subset cue precludes meaningful differentiation of the magnitude of the effect. Regardless of the magnitude of the decrement, however, differences in the types of errors committed during PA learning and in recall indicate that two different processes were probably responsible for the decrements obtained with the two types of subset cues. With nouns, the decrement appeared to be due primarily to confusion among pairs within subsets, while with CVCs, the decrement was caused primarily by confusion among pairs both within- and between-subsets.

Most of the decrement in the 2-noun-subset condition relative to the 0 condition was due to omission errors. However, the further decrement from 2 through 8 noun-subset conditions consisted almost entirely of Within-errors. There was confusion, therefore, among items sharing a common subset cue. Moreover, the confusion became greater as more cues were added to the list, as shown by the increasing difference between within- and between-errors relative to expected errors. If most of the decrement was due to within-subset confusion, Ss probably formed associations between the subset cues and the response terms comprising the subset. Recall scores indicate that Ss did form such associations. When Ss were presented with the subset cue in recall and required to give the responses paired with them (CR_p), consistently more correct pairings were obtained than expected by chance. Furthermore, as the number of cues increased, the above chance pairings also increased until with 8 subset cues, performance was virtually perfect. That the superior recall under noun-subset conditions with an increase in number of added cues is not due entirely to the increase in number of pair presentations during PA learning is indicated by the fact that recall performance with CVC subset cues did not improve with an increase in trials to criterion; if anything, recall performance was poorer as Ss required more trials to master the list. Thus, the results taken together strongly suggest that as more noun subset cues are added to the list, Ss utilize these cues to a greater extent to organize the pairs into subsets, even though such organization impedes the formation of specific stimulus-response associations within subsets.

When CVCs were subset cues, the decrement in PA performance was not limited to within-subset interference, but also manifest in omission and between-subset errors as well. This suggests that the addition of low-meaningful cues decreased discriminability among the pairs in the list. Indicative of such interpair confusion was the finding of significantly more between-subset errors relative to chance early in learning. By the third quarter of the

learning trials, most of the between-subset confusion had been resolved. This suggests that Ss learned progressively more about the contingencies and/or learned to ignore the CVCs and PA learning progressed. That Ss did learn something about CVC contingencies is shown in recall by significantly more correct pairings of responses with CVC subset cues than expected by chance. Following this reasoning it would be expected that Ss should also have committed relatively more within-errors than controls. While the data provide no support for this expectation, the paucity of within-errors in the present research when nouns served as stimuli does not allow for a sensitive test of the prediction. In this same connection, it should be noted that while the increased decrement in PA performance with an increase in number of CVC subset cues indicates that Ss attended more to these cues as more of them were added to the list, recall performance shows that there was no corresponding increase in the ability of Ss to pair correctly CVC cues and response terms. It seems, therefore, that any increased attention to CVC subset cues did not lead to increased learning of specific associations between CVCs and response terms.

Comparison of single (Cond 0) and nonoverlapping compound stimuli (Cond 16) indicated that there was a large facilitation in learning under the compound condition if the element added to form the compound was of higher meaningfulness than the single stimulus. The facilitation was considerably greater than that obtained by Cohen and Musgrave (1964). While the discrepancy may be due to differences in materials used in the two studies, it seems more likely that the longer list used in the present study (16 items rather than 6) provided for a more sensitive task. It should also be noted that the present facilitation occurred even under conditions where the position of the added stimulus element varied within the compound from trial to trial. On the other hand, Cohen and Musgrave reported facilitation only when the added element was to the left of the low-meaningful unit.

The present facilitation with nonoverlapping compound stimuli can be explained by stimulus selection. With no stimulus overlap (i.e., no stimulus repeated in the list), either element of the compound can act as the functional stimulus. Consequently, the more meaningful item is selected more often in the associative process. Consistent with this interpretation are the recall findings which showed virtually perfect response recall to the noun component of the compound, in agreement with previous results obtained by Underwood, Ham, and Ekstrand (1962). Also in agreement with the Underwood, et al. study there is evidence to suggest in the present research that Ss did not completely ignore the CVC component of the compound stimulus. This was indicated first by the slightly inferior PA performance in Cond 16 Ss as compared to the 0 condition which presented nouns as PA stimuli. If Ss completely ignored the CVCs in learning, performance under these two conditions should have been identical. Secondly, the recall data indicates that while SR_p performance of Cond 16 Ss with CVCs presented was poor, Ss were still able to pair correctly a few of the response terms with their CVC component, thereby indicating that some associative learning had taken place.

To summarize, the present research shows that subset cues of both higher and lower meaningfulness than PA stimuli retard learning, and that this retardation tends to increase with an increase in number of added cues. With noun cues, the interference was due primarily to within-subset interference, while with CVCs, the interference was of a more general nature, involving pairs within- and between-subsets. With no stimuli repeated (nonoverlapping compound stimuli) there was a relative facilitation in learning. These results thus suggest that the functional relationship between PA performance and number of added cues is discontinuous; i.e., facilitation will not occur until some or all of the added cues appear with single responses.

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Appendix 1

Paired-Associate Learning Instructions

This experiment is designed to study your ability to remember verbal associations. In front of you is a black screen with a pocket at the bottom. I will place a card in this pocket. On the right-hand side of this card will be printed the name of a common occupation. [The left side will contain two items: one a common noun, and the other a three-letter syllable, which is not a word at all.], or [The left side will contain a (common noun, 3-letter syllable which is not a word at all).]

Your task is to learn to associate the right-hand occupation with the left-hand item(s) on the card. In order for you to do this, you will first see the card containing both left- and right-hand items. You will be allowed to study this for three seconds. Later I will show you only the left-hand item(s) and ask you to call out the occupation name which was previously associated with (them, it).

You will be asked to learn more than one card. In all, 16 different cards will be used. Thus, first you will be shown 16 cards, one at a time, each containing both left- and right-hand items. Study each of these. Then you will be shown the 16 cards again, but this time the right-hand occupation name will not appear. Only the (word and syllable, word, syllable) on the left of each card will be presented. During this test part, you will have three seconds in which to say the occupation name which previously appeared on the right-hand side of the card.

After you have completed this, you will be allowed to study the cards again, followed by another test over them. We will continue this procedure of study and testing throughout the session. During any test trial, if you are not sure of the correct response, please guess. You should respond to all items during each test trial.

Are there any questions?

Appendix 2

LISTS USED IN NOUN-SUBSET CONDITIONS

	Subset Cue				
Cond 2	Cond 4	Cond 8	Cond 16	PA Stim.	Response
TABLE	TABLE	OCEAN	OCEAN	WUG	DENTIST
			GLASS	CEF	HUNTER
		TABLE	NIGHT	MIV	CASHIER
			BODY	PYM	RANCHER
	DOOR	DOOR	DOOR	QUC	FIREMAN
			EDGE	TIW	LAWYER
		FAMILY	FAMILY	NYD	ARTIST
			TABLE	XAS	PLUMBER
CITY	CITY	CITY	CITY	DOJ	BANKER
			INCH	KEZ	TAILOR
		MARKET	MARKET	FAQ	EDITOR
			KING	VOB	SURVEYOR
	PARTY	PARTY	PARTY	BYH	GARDENER
			SEASON	JEX	MILKMAN
		ARMY	ARMY	GIK	JEWELER
			LETTER	ZUL	WAITER

LISTS USED IN CVC-SUBSET CONDITIONS

SUBSET CUE				PA STIM.	RESPONSE
Cond 2	Cond 4	Cond 8	Cond 16		
MIV	MIV	WUG	WUG	OCEAN	DENTIST
			CEF	GLASS	HUNTER
		MIV	MIV	NIGHT	CASHIER
			PYM	BODY	RANCHER
	QUC	QUC	QUC	DOOR	FIREMAN
			TIW	EDGE	LAWYER
		NYD	NYD	FAMILY	ARTIST
			XAS	TABLE	PLUMBER
XAS	XAS	DOJ	DOJ	CITY	BANKER
			KEZ	INCH	TAILOR
		XAS	FAQ	MARKET	EDITOR
			VOB	KING	SURVEYOR
	BYH	BYH	BYH	PARTY	GARDENER
			JEX	SEASON	MILKMAN
		KEZ	GIK	ARMY	JEWELER
			ZUL	LETTER	WAITER

Appendix 3

INSTRUCTIONS FOR SUBSET-CUED AND STIMULUS-CUED RECALL

I will now give you a sheet of paper on which you will find the (words, syllables) which were on the left side of the cards you studied. Your task will be to write the occupation names which were previously paired with each (word, syllable). It is important that you write down as many of the previously learned occupations as you can remember, so if you are not sure which (word, syllable) an occupation was paired with, please guess.

Are there any questions?

INSTRUCTIONS FOR FREE RECALL

I will now give you a sheet of paper. Your task is to list on it all of the occupation names which you can remember that appeared on the right-hand side of the cards you previously studied. Please list them in the order in which they come to mind.

Are there any questions?

INTRALIST CATEGORIZATION: THE EFFECT OF ADDING A SECOND STIMULUS TO SUBSETS OF PAIRED ASSOCIATES

by

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Previous research (Brown & Sanford, 1968) presented a method whereby organization in verbal learning could be examined by the addition of subset cues to a paired-associate (PA) list. The previous research found that the addition of highly meaningful subset cues led to a decrement in PA performance and that the decrement was due primarily to an increase in responses from pairs within the same subset as the correct response. The previous research, however, did not systematically vary the number of subset cues present in the list. The primary aim of the study, therefore, was to determine the nature of the relationship between number of subset cues and their relative effect on PA performance. In addition, relative meaningfulness of PA stimuli and subset cues was varied.

Nine groups of subjects (Ss) learned a 16-item PA list to a criterion of one errorless trial using the pairing-test (recall) method. Eight of the groups formed a 4 X 2 factorial design, varying with respect to (a) number of subset cues added to the list (either 0, 2, 4, or 8); and (b) relative meaningfulness of stimuli and subset cues (low and high). The ninth group received 16 extra stimuli, and thus learned a list composed of 16 nonoverlapping compound stimuli. Sixteen Ss participated in each condition, except in the nonoverlapping compound stimulus condition, where n = 24. Five minutes after completion of PA learning, each S was required to recall the responses from the list under one of the following conditions: (a) free recall (no cues present); (b) PA stimulus-cued recall (stimuli present); and (c) subset-cued recall (subset cues present).

The results indicated that PA learning was significantly retarded with subset cues present, as compared to control groups having only single stimuli. Furthermore, the decrement became greater as more cues were added, whether the cues were of higher or lower meaningfulness than the PA stimuli of the list. With subset cues of relatively higher meaningfulness, the decrement was due

primarily to confusion among pairs within the same subset, replicating the previous results, while with subset cues of relatively lower meaningfulness, the interference was of a more general nature involving all of the pairs in the list. When each pair in the list appeared with a different second stimulus term (nonoverlapping compound stimuli) there was a shift to relative facilitation. The results likewise suggest that the functional relationship between PA performance and number of added stimulus cues is discontinuous; i.e., facilitation will not occur until some or all of the added stimuli appear with single responses.