Association by contiguity: Clustering in free recall

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Unrelated words were randomly paired then presented in a verbal discrimination (VD) task. After VD learning, the 24 words were used in a typical multitrial free recall (FR) situation. Analysis of clustering in FR revealed that contiguous presentation of words during VD learning induced Ss to recall the words together. Association by contiguity appears to be one determinant of clustering (organization) of output order in FR.

The distinguishing feature of the method of free recall (FR) is that S is under no instructional constraints regarding the order of emission of recalled items. Several experiments have shown that various types of identifiable grouping arrangements occur in the protocols of Ss under FR conditions such that particular items tend to be recalled together (Schuell, 1969). For example, categorical clustering occurs if a list of words is drawn from two or more mutually exclusive conceptual classes (Bousfield, 1953); associative clustering is found if cultural or preexperimental stimulus-response associates comprise the FR list (Jenkins & Russell, 1952).

In a recent analysis of verbal organization, Wallace (1970) has argued that organization of recall order is an associative process in which the mechanism underlying associative strength is contiguity of experience. As Wallace notes: "The principle of contiguity as applied to order of free recall states that *there is a tendency to recall together items which have been experienced together* [p. 59]." If the contiguity principle is a factor in organization in FR, it should be possible to induce clustering experimentally by exposing unrelated items in close temporal contiguity prior to the FR task. The specific nature of the pre-FR exposure conditions should be reflected in the organization of FR output.

The verbal discrimination (VD) learning task, in which S is presented with a list of word pairs and is to discover which member of each pair has been arbitrarily designated as correct by E, is well-suited for pre-FR exposure of unrelated words in close temporal (and spatial) contiguity. In fact, several experiments have indicated that some degree of associative strength is built up between the two unrelated members of VD pairs, even though S is not instructed to learn associations (e.g., Keppel, 1966; Spear, Ekstrand, & Underwood, 1964). Thus, if associative learning occurs in the VD task via the contiguity principle and if FR organization is an associative process, clustering of VD pairs should be obtained on the FR task. Experimentally induced clustering would represent an extension of Jenkins & Russell's (1952) finding that cultural associates tend to be recalled together in FR. Fulkerson & Kausler (1969) demonstrated considerable clustering of VD pairs on a single trial of free recall immediately following the criterion trial in a VD task. The present study was designed to determine if such VD pair clustering is larger than chance and if the clustering would remain stable with repeated trials of free recall learning following attainment of a VD criterion.

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METHOD

The basic materials were 24 three- and four-letter monosyllabic nouns with Thorndike-Lorge G-count frequencies ranging from 1-48. Each word began with a different letter. The words were as semantically and structurally unrelated as possible, and interitem associative connections among them were minimal. First, the words were randomly paired (List A), then another random pairing was made such than each word was paired with a different word than in List A (List B). Each list was used as the 12-pair VD list for half the Ss. Within each list one member of each pair was designated the correct member for one version of the lists. For a second version of each list the other member of the pair served as the correct item. Each version was used for half the Ss receiving each list; therefore, each word served as a correct and an incorrect item equally often in the course of the VD learning. Since each word was paired with two words, VD (contiguous) and arbitrary (noncontiguous or control) pairs for a given S were defined as follows: (1) contiguous pairs were those pairs of S's particular VD list and (2) noncontiguous pairs were those pairs from the list that S did not receive in VD learning.

All material was presented on a Lafayette memory drum. Four random orders of the pairs in each list were formed for VD learning, and each order served as the starting order approximately equally often. The pairs were presented at a 2:2-sec rate with a 2-sec intertrial interval. The words of each pair appeared across from each other in the first 2-sec interval, and S was to call out the correct member. In the second 2-sec interval both members of the pair appeared again, in the same order, with the correct member underlined. The Ss were instructed to respond during the first 2-sec interval on all trials, including the first. On a particular trial, half the items in each spatial position were correct. In each block of four trials each word appeared in the left spatial position twice and in the right position twice. The VD list was learned to a criterion of one errorless trial.

After VD criterion was reached, E read instructions for FR learning. Prior to the first presentation of the words for FR, Ss were asked to recall the VD words. The time allowed for this first recall and all subsequent recalls was 90 sec. Word recall was written, and Ss used 9-page booklets containing 24 lines per page with 12 lines per column. The Ss were asked to recall the words in any order and to write them down starting in the first column. After the first recall that followed VD learning, Ss were given eight alternating study and test FR learning trials. Four random orders (subject to restrictions as described below) of presentation of the words were constructed. No word occupied the same serial position in more than one order, and members of VD pairs were *never* presented in succession. According to the VD designation of pairs, in each FR order half of the pairs appeared in the order correct-incorrect and half in the order incorrect-correct. In two of the orders the correct member of a given pair appeared first and in the other two orders the incorrect member of a pair appeared first. The words were presented at a 1-sec rate, and a three-digit number followed immediately after the last word in each order. To partially eliminate organization of output resulting from the recency effect, recall was delayed for 10 sec following the last item by having S count backwards by twos from the number. Five seconds following the 90-sec recall period, S was alerted to watch the drum, and the next presentation began.

Table 1
Mean Number of Clusters Per Trial

Type of Cluster	Trials 1	2	3	4	5	6	7	8	9
Contiguous	3.10	2.05	2.35	2.05	2.35	2.40	2.35	2.95	2.70
Noncontiguous	.25	.40	.25	.55	.70	.85	.85	.65	.85

The Ss were 20 male and female undergraduates who were fulfilling a course requirement in introductory psychology. Ten Ss were assigned randomly to VD List A, and the remaining received List B.

RESULTS AND DISCUSSION

The mean number of trials to criterion on the VD list was 6.95. FR protocols were scored by counting the number of contiguous and noncontiguous clusters recalled. A contiguous cluster was defined as recall of the two members of a VD pair in succession. Noncontiguous clusters were VD pairs from List B, if S practiced List A on the VD task, or VD pairs from List A, if S received List B in VD learning. Since pairs which were noncontiguous for half the Ss were contiguous pairs for the other half of the Ss, amount of noncontiguous pair clustering gives an empirical estimate of clustering attributable to chance and to other factors not related to the contiguous presentation of the members of a pair on the VD task.

The total number of contiguous clusters for Ss in the List A subgroup was 206; this value for the List B subgroup was 240. These scores do not differ significantly ($t = .55$). The total number of noncontiguous clusters was 50 and 57 for List A and List B subgroups, respectively. These latter scores are also not reliably different ($t = .46$). In view of the above, the two subgroups were combined for further analyses. The mean numbers of the two types of clusters over the course of FR learning are presented in Table 1. More contiguous than noncontiguous clusters were recalled. A randomized block factorial analysis of variance indicated that this effect was highly significant, $F(1,323) = 150.36$, $p < .001$. The effect of trials was not significant, $F < 1$. Also, the interaction of cluster type with trials fell far short of significance, $F < 1$.

The mean number of words recalled, of course, increased over trials. The nine means for Trials 1-9 were: 10.85, 13.05, 15.55, 16.65, 17.45, 18.75, 18.90, 20.50, and 20.35. Some views of memorial organization suggest that degree of organization should be positively correlated with amount recalled. In this experiment the correlation between contiguous clustering and total recall, while positive, was far from significant [$r(18) = .21$, $p > .10$].

The present data indicate that the contiguous presentation of unrelated words during VD learning induced Ss to recall the words together on the FR task. Wallace's (1970) emphasis on the principle of contiguity as a factor in organization of recall is consistent with these results.

The organization obtained in this experiment can be considered associative clustering (see above) where the clustering of the preexperimentally unrelated items is attributable to the contiguous exposure of the items prior to FR learning. Wallace (1969) has recently obtained laboratory induced clustering when unrelated words wery presented successively during the study trial in a modified FR experiment. In sum, the present data, together with Wallace's, suggest that organization of recall order can be influenced by contiguity relations between pairs of items.

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Stimulus alternation and continuous short-term memory in young children*

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The effect of the number of interpolated trials on the stimulus alternation behavior of kindergarten children was investigated in a free-choice task. Three sets of stimuli were used for both interpolation and test trials. Stimulus alternation decreased markedly from 0 to 1 interpolated trial and then remained relatively constant, but significantly above chance, over 1, 2, and 3 interpolated trials. The relevance of the findings to stimulus alternation theory and the study of continuous short-term memory in young children was discussed.

In a number of recent experiments (Harris, 1965, 1967; Rabinowitz & DeMyer, in press), evidence was obtained indicating that children between 4 and 6 years old alternate stimuli. In order to explain this phenomenon, it is necessary to postulate some trace on Trial n + 1 of the events occurring on Trial n (see Dember & Fowler, 1958). Whatever the nature of the trace, it should be susceptible to interference. The present experiment was designed in order to: (1) investigate the deterioration rate of trace elements used by young children when they alternate stimuli in a situation in which both proactive and retroactive interference occur; and (2) develop a technique that is useful in studying continuous short-term memory in young children.

*The research was conducted in the Shoreline School District, Seattle, Washington. The authors are extremely grateful for the cooperation they received from teachers and administrators in the Shoreline System. Special thanks are due to Stanley Wiklund, Principal of Ridgecrest Elementary School, William Randall, the Director of Research, and Daniel Marken, Research Associate.

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