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Processes Underlying Clustering in Fee Recall

Toshiaki Mori
Hiroshima University

In free recall *S* is presented a list of words to learn, and he is told to recall the items in any order he wishes. Interestingly, certain regularities appear in the order in which the items are recalled. For example, there is a tendency for items which belong to the same category to be recalled together even though these items were not contiguous during presentation. This tendency for items belonging to the same category to be recalled together has been termed clustering.

A long line of studies, beginning with the experiment by Bousfield (1953), have been concerned with this phenomenon of clustering, and have shown that clustering is a function of many variables, such as number of categories (Bousfield & Cohen, 1956; Dallett, 1964; Mandler, 1967), type of category (Cohen, 1963a; Cohen, 1963b), presentation order of words (Cofer, 1967; Cofer, Bruce, & Reicher, 1966), rate of presentation (Cofer, Bruce, & Reicher, 1966), frequency of words (Bousfield, Cohen, & Whitmarsh, 1958; Segal, 1969), and developmental level of subjects (Bousfield, Steward, & Cowan, 1964; Mandler & Stephens, 1967).

However, the processes underlying clustering in free recall are so far only dimly understood. One of the most fundamental questions to be clarified is whether clustering occurs during storage or at the time of retrieval. Tulving (1968) has argued that items are stored in some coded fashion. The coding may take the form of unitization (chunking) of related items into the functional units. This coding is assumed to take place during storage. If categorized words comprised the list, *S* might recode them by forming chunks which could be tagged with the category label. At the time of retrieval, *S* merely has to recall the category label and reproduce the items from that category, consequently producing output organization. Slamecka (1968), on the other hand, put forth a different explanation of the clustering phenomena. He assumed that the specific item traces are being stored independently and the pattern of output organization reflects the nature of the retrieval process. This question of whether item traces are originally arranged into cohesive groups during storage, or this organization comes into being only at retrieval has been the subject of some debate but has not been yet satisfactorily resolved.

One way of attempting to answer this question would be to inform *S* at time of retrieval that the words could be put into categories, while preventing him from detecting the structure of the list during presentation. In the present study, an incidental learning task was employed to prevent *S* from detecting the structure of the list. If clustering occurs during storage, such information given at the time of retrieval could not facilitate clustering. If, on the other hand, clustering occurs during the retrieval process, the information at the time of retrieval should facilitate clustering. Experiment I was, therefore, designed to investigate whether providing information on the list structure at the time of retrieval facilitates clustering in free recall.

Experiment I

Method

Subjects. Seventy-eight college students served as *S*s. They were respectively assigned to one of the five conditions according to the order of their appearance at the laboratory. Twenty-eight *S*s were discarded from the analysis because they failed to follow instructions.

Materials. Four different lists of 24 words (nouns) were used. Lists A and B were used for the incidental learning task, both of which consisted of 8 words from each of 3 conceptual categories, namely, flower, vehicle, and clothing. The words of List A were the most frequent category members, and those of List B were the infrequent category members. Lists C and D were used for the intentional learning task. List C consisted of 8 most frequent words from each of 3 categories, namely, fish, fruit, and musical instrument, and List D consisted of 24 unrelated words.

Design The basic design was a 2 by 2 factorial, with frequency of words for incidental learning task (High Frequency or Low Frequency) as one factor, and information condition (Information or No Information) as the other. In addition, a control condition was employed, in which a categorized word list (List C) was used for an intentional learning task.

Procedure. Words were presented in pairs on a memory drum at a 4 sec rate. Words for intentional learning task were presented on the left side, words for incidental learning task presented on the right side. *S*s in experimental groups were presented List D on the left side for intentional learning task, and List A or B on the right side for incidental learning task. *S*s in the control group were presented List C on the left side for intentional learning task, and List A on the right side for incidental learning task. To discourage left-right combination learning, different pairings occurred on successive trials. The lists were presented twice with a 4 sec interval between successive presentations in two different random orders. The experiment was introduced as a study on the effects of distraction on memory. *S* was instructed to pronounce out loud the left word and then the right one. Each S was instructed to memorize only the left words. *E* explained that he was interested in finding out how saying the "irrelevant" words, a distraction, affected learning of the "relevant" words. Then S had a 5 min recall period to write down the "irrelevant" words in any order S pleased. *S*s in the information condition were given the information that the words could be put into categories and were given category names, while *S*s in the control group were not given such information. Subsequent to the free recall test of the "irrelevant" words, *S* was instructed to write down the "relevant" words in any order and was allowed 5 min for this. Next were two 5-point self rating scales on efforts made to learn the "irrelevant" words and on the expectation of being tested on the "irrelevant" words. The scale points were: "Not at all," "A little," "Moderately," "A great deal," and "As much as the relevant words." Only the data from *S*s marking "Not at all" in both scales were retained as true incidental *S*s. Finally, category detection was checked by asking if *S* noticed any relationship among the words and if so, whether he noticed categories during presentation of words or during recall.

Results

Major findings of Experiment I can be summarized under the following headings.

Mean number of categories detected. Mean numbers of categories detected during the presentation are shown in Table 1. Most of the categories were detected in the control group while only a few categories were detected in the experimental groups. The separate t tests between the control group and each of four experimental groups indicated that Ss in the control group detecged more categories than Ss in experimental groups in incidental learning (Control>High-Information, High-NoInformation, Low-Information, and Low-No Information, t=6.93, df=18, p<0.001; t=4.93, df=18, p<0.001; t=3.95, df=18, p<0.001; t=5.94, df=18, p<0.001, respectively). There was no significant difference among the four experimental groups on the number of categories detected. These results indicate that using an unrelated word list for intentional learning task degraded the category detection of the incidental learning list in the experimental groups.

Mean adjusted ratio of clustering (ARC) score. The adjusted ratio of clustering (ARC) score introduced by Roenker, Thompson, and Brown (1971) was used as the measure of clustering, in which chance clustering is set at zero and perfect clustering at one. Mean ARC scores are shown in Table 1. Although *S*s in the control group showed a considerable amount of clustering, *S*s in the experimental groups showed clustering near to chance level in incidental learning. The separate *t* tests between control group and each of the four experimental groups indicated that the control group clustered significantly more than the experimental groups High-No Information, Low-Information, and Low-No Information (t=2.58, df=18, p<.02; t=2.58, df=18, p<.02; t=3.03, df=18, p<.01, respectively). Providing information at the time of retrieval that the words for the incidental learning task could be put into categories did not facilitate clustering in either level of frequency condition.

Table 1

Mean ARC Score and Number of Categories Detected in Incidental Learning Task

Groups	Categories Detected	ARC
High-Information	0.20	0.16
High-No Information	0.40	−0.11
Low-Information	0.50	0.01
Low-No Information	0.30	−0.15
Control	2.30	0.43

Discussion

Experiment I was designed to investigate whether clustering in free recall occurs during storage or at the time of retrieval in human memory. The primary results of interest were that the control group, in which most of the categories were detected during the presentation, showed a considerable amount of clustering, but the experimental groups did not show clustering even when the information on list structure was provided at the time of retrieval. These findings are in general agreement with those of Hudson (1969): those Ss who were instructed before word presentation that the words could be categorized clustered significantly more than those Ss who were instructed after word presentation on the list structure or those Ss who were not given such information. The present findings also seem to be consistent with those of Tulving and Osler (1968) that the retrieval cue for the to-be-remembered word must be stored with the word at input if it is, in fact, to be a retrieval cue.

Slamecka (1968) has proposed another, quite different model to account for clustering often observed in free recall studies. According to his model, organization is not achieved at storage but rather at retrieval as the result of the search plan. Slamecka (1968) has further suggested, while discussing incidental learning, that if *S*s were given a retrieval plan at the time of retrieval, output organization should increase. However, the present findings that providing information on list structure does not facilitate clustering do not support his prediction. Further, it should be noted that providing information does not facilitate clustering even under the condition in which the most high frequency words were used.

In summary, the main conclusions to be drawn in Experiment 1 are that words should be stored in cohesive groups to produce clustering at the output, and the independent storage model for memory is inadequate to account for clustering in free recall.

Experiment II

In Experiment I, it was found that clustering reflects the dependent storage process of human memory. The next question to be clarified is whether organizational units are initially formed in the short-term or in the long-term store.

Several investigators have argued that there are two separate storage mechanisms present in free recall, a long-term store (LTS) and a short-term store (STS), and assumed that the recall of items from the terminal input positions should primarily reflect the amount of material stored in STS, whereas that from preterminal input positions should reflect the amount of material stored in LTS (Atkinson & Shiffrin, 1968; Glanzer & Cunitz, 1966; Waugh & Norman, 1965).

Inferences about the temporal locus of organization have been based primarily on the relation between serial position in input and organization in output. With respect to semantic organization, the experimental findings are inconsistent: Grouping effects have been found to be independent of serial position in some investigations (Glanzer, 1969; Glanzer & Meinzer, 1967) but not in others (Tulving & Patterson, 1968). It seems necessary, however, to re-evaluate the conclusions drawn in these studies by analysing the output order of the list since output order was analysed in none of these studies. Furthermore, no evidence has been provided in these previous studies that the recall of the items from the terminal input positions was actually the output from STS. One approach to solve this problem is to introduce the condition in which recall is delayed for a brief time, the interpolated interval being filled with activity assumed to displace the items stored in STS. If, the activity during the delay period does not affect the recall of the items from terminal input positions, the recall of these items should be regarded as the output from LTS even if they are presented at the terminal positions of the list.

Method

Subjects. Forty-eight college students served as Ss. They were respectively assigned to one of the two conditions according to the order of their appearance at the laboratory.

Materials. Four different lists of 19 words were used. Each list consisted of 9 highly related words (R words), 3 high-frequency members from each of 3 categories, and 10 unrelated words (U words). R words from the same category were distrubuted at the beginning (serial positions of 1, 3, and 5), in the middle (serial positions of 8, 10, and 12), and at the end (serial positions of 15, 17 and 19) of the list. U words occupied remaining serial positions of the list. The order of the categories and the order of the words within each category were counter-balanced.

Design. Ss were divided into two groups (Immediate Recall and Delayed Recall). The Immediate Recall group was asked to recall immediately following the presentation of the list, while the Delayed Recall group was delayed for 30 seconds by a task which was intended to displace the items stored in STS.

Procedure. Each *S* was tested individually once under one of the two conditions. The words were presented on a memory drum at a 2 sec. rate. Immediately following the presentation of the list, *S* in Immediate Recall was instructed to recall as many words as they could in any order, within the 60 sec period. As soon as the last item was presented, *E* gave a three-digit number and *S* in Delayed Recall was told to count backwards from that number by threes as rapidly as possible. After 30 sec , he was told to begin free recall of the list, and was allowed 60 sec. for this task. Each *S* learned and recalled all of four different lists successively with counter-balanced orders.

Results

Major findings of Experiment II can be summarized under the following headings.

Mean adjusted ratio of clustering (ARC) score. Mean ARC scores for R words distributed at the beginning, in the middle, and at the end of the list are shown in Table 2. As shown in Table 2, a considerable amount of clustering was observed irrespective of the serial position of R words in the input list. No difference was observed on clustering between Immediate Recall and Delayed Recall conditions. Analysis of variance was carried out with recall condition (Immediate Recall and Delayed Recall) as a between-*S* variable, and serial position as a within-*S* variable. Neither variable nor their interactions were significant.

Table 2
Mean ARC Score of Related Words

Groups	Serial Position		
	Beginning	Middle	End
Immediate	0.78	0.81	0.75
Delayed	0.78	0.84	0.82

Proportion of words recalled. The serial position curves for Immediate Recall and Delayed Recall are shown in Fig. 1. Inspection of Fig. 1 reveals that R words were recalled more frequently than U words in each recall condition (Immediate Recall, $x^2 = 71.33$, $df=1$, $p<.001$; Delayed Recall, $x^2 = 100.03$, $df=1$, $p<.001$, respectively). Moreover, it should be noted that the recall of R words at the end of the list was not reduced in Delayed Recall although the probability of recall of U word (the item in Position 18) was reduced in Delayed Recall ($x^2 = 30.4$, $df=1$, $p<.001$).

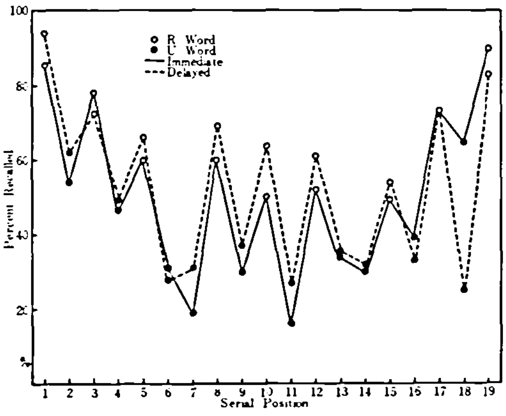

Fig. 1. Serial Position Curves for Immediate and Delayed Recall Conditions.

Discussion

The purpose of Experiment II was to investigate whether clustering occurs in STS. The results indicated that a considerable amount of clustering occurred irrespective of the serial position of R words. These results are inconsistent with the conclusions of Tulving and Patterson (1968) that the terminal list items are stored independently. In order to examine that unitization takes place in STS, Tulving and Patterson (1968) presented *S* with lists of varying length for free recall. In their experimental lists, the four words at the end of each list belong to a single category, while for the control lists, all of the words were unrelated. They argued that if unitization occured in STS, then an equivalent number of functional units would be recalled in the two conditions. No evidence of unitization was found in their experiment. When recall was scored by counting each unrelated word as a functional unit and the category as a unit, regardless of the number of words recalled from the category, there were few functional units recalled for the experimental lists. On the basis of this measure, Tulving and Patterson (1968) concluded that the related words did not act like a single unit in STS. In the present study, however, the R words at the end of the list were recalled together even though they were not contiguous during the presentation. These results should be interpreted as indicating that the R words at the end of the list were organized into a functional unit.

Moreover it should be noted that the activity during the delay periods did not reduce the recall of the R words at the end of the list. An activity during the delay periods has been shown to displace the items stored in STS (Glanzer & Cunitz, 1966; Postman & Phillips, 1965). The results obtained in the present study, therefore, can be interpreted as evidence that the R words at the terminal input positions were transferred to LTS. Considering the findings that the recall of U words at the end of the list was reduced in Delayed Recall, it can be concluded that the unitization of related items plays an important role in tranferring them to LTS.

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