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Clustering and Subjective Organization of Free Recall Learning

Sandra Gail Harrell Fenner

CLUSTERING AND SUBJECTIVE ORGANIZATION OF FREE RECALL LEARNING

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Sandra Gail Harrell Fenner

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This thesis submitted by Sandra Gail Harrell Fenner in partial fulfillment of the requirements for the Degree of Master of Arts from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

Robert S Beecroft
(Chairman)

R H Kolstoe

Paul A Wright

William Johnsen
Dean of the Graduate School

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ABSTRACT

Two concepts, clustering and subjective organization, have figured prominently in theoretical explanations of free recall learning. With lists composed of categorized words (e.g., animals, vegetables, occupations), subjects tend to order recall by categories, which tendency is called clustering. There is much experimental evidence for a relationship between clustering and amount recalled, as recall and clustering have been shown to increase with repeated presentations of the material. Curiously, there is some evidence that the degree of clustering seems to be uncorrelated with recall scores, that is, subjects who cluster strongly do not recall more words than subjects who cluster less strongly (Puff, 1970). There is also experimental evidence that subjects recall more from a categorized list than from a non-categorized list; however, most of these studies have been of the single trial variety.

Subjective organization is a concept developed in connection with multitrial free recall studies with non-categorized lists. Regularities in recall sequences from one trial to the next, particularly in the later stages of practice, define subjective organization. Subjective organization has been found to be strongly related to recall, that is, subjects who show strong organization recall more words than subjects who show weaker intertrial organization (Tulving, 1962, 1964).

In the present study 30 female college students were exposed to two mixed lists, containing both categorized and non-categorized words for ten trials. Each list consisted of three categories with eight exemplars per category and 12 experimentally unrelated words. The material was presented aurally by means of a stereo tape deck and earphones.

Recall increased across trials in the form of a negatively accelerated exponential function from 36 percent of the list items on the first trial to 72 percent on the tenth trial. A category effect was highly significant for Trial 1, $t=8.03$, $p < 0.001$ but from Trial 2 onward there was no difference in the recall of categorized or non-categorized words. The mean clustering (Adjusted Ratio of Clustering) value rose from .30 on Trial 1 to .66 on Trial 10. A measure of organization, Organization by Pairs of Trials (OPT), increased from 1.4 pairs recalled on Trials 1 and 2 to 5.2 on Trials 9 and 10. Correlations were computed between clustering and recall, organization and recall, and clustering and organization. The results indicated an increase over trials in the correlation coefficient for all three relationships.

CHAPTER I

HISTORY OF THE PROBLEM

Organization as a Factor in Recall

A number of theorists have proposed that organization is the fundamental process facilitating the recall of verbal material in a free recall task (Tulving, 1962, 1968; Bower, Lesgold and Tieman, 1969; Mandler, 1967; Cofer, 1967). In a free recall task, subjects are presented a list of verbal items which they are required to recall. The materials may be presented orally or in written form for the subject to study a brief period of time before he is asked to recall. Tulving (1968) distinguished between two types of organization in free recall, primary and secondary organization. Primary organization is organization imposed upon the material by the experimenter, such as meaningfulness or input order, which may influence the subject's recall. Another example of primary organization is the recency effect, which is the tendency for subjects to recall the last items presented in a list before any of the other items, regardless of any relationships among the items or the subject's prior experience with the items. Secondary organization is dependent upon the subject's prior experience with the items and more specifically is influenced by relationships among the items, whether it be in respect to meaning or phonetic characteristics. The present study deals with two types of secondary organization, clustering and subjective organization. The concept of

clustering was originally formulated by Bousfield (1953), and subjective organization has been described by Tulving (1962).

Tulving (1968) summarized the experimental conditions of clustering and subjective organization. Clustering occurs when: (1) Items in the presented material are composed of distinct semantic categories selected by the experimenter. (2) Input order of the material is randomized. (3) Output order is arranged such that items within a single category follow each other more than would be expected by chance. Although most of the early studies have dealt with clustering in single-trial output, recent studies have investigated the relationship between clustering and amount recalled in multi-trial input and output. The present study deals with multi-trial recall. Subjective organization requires more than a single recall of the material. It is applicable to both categorized and non-categorized material. Subjective organization is inferred when two or more items occur together or in close contiguity over different output phases. Subjective organization implies that the subject imposes his own organization upon the material he is trying to remember.

Bower, Lesgold and Tieman (1969), did a series of experiments which they interpret as supporting the belief that subjects group or subdivide material into subjective clusters which become integrated units in recall, thereby serving as the basic mechanism in learning free recall material. In Experiment I subjects were given three free recall trials on each of four lists of 24 experimentally unrelated nouns, each list divided into six quartets. Subjects were presented four words at a time and asked to imagine something involving all four. The quartets varied over the three trials for two lists and

remained the same for the other two lists. It was found that the recall of the lists repeated with the same grouping significantly improved with practice. In Experiment II, subjects learned two lists of 36 unrelated words to a criterion of 32 words and then sorted the 36 words into nine groups of four words each, according to how they thought the words belonged together. Subjects were then given another input trial for each list. The input trial was consistent with the subject's quartet grouping for one list, and for the other list it was systematically inconsistent with the subject's sorting. In both conditions, the subjects were instructed to visualize together the words presented in a given quartet. All subjects increased their recall after the consistent trial; a majority of the subjects decreased their recall after the inconsistent trial. In Experiment III subjects learned two lists in a counter-balanced order. Each list of 75 words was comprised of 25 triplets presented with mental imagery instructions. Subjects were given two input-output cycles of free recall for each list. The 25 triplets were repeated on the second trial for a same-groupings condition; for a changed-groupings condition the 75 words were arranged into different triplets. There was no difference in the same and changed conditions on a recognition test, but recall improved significantly from Trial 1 to Trial 2 for both conditions, and more so for the same condition. Experiment IV dealt with the hypothesis that subjects having increasing group sizes will recall better than subjects having decreasing group sizes. Subjects were given three input-output cycles on a list of 60 nouns, randomly composed into 20 triplets. Two random triplets were given into 20 triplets. Two random triplets were combined to form ten 6-tuples and two random 6-tuples were combined to form five

12-tuples. Half the subjects received the list groupings, half the subjects received the reverse order. A highly significant finding was that subjects in the increasing condition improved at a faster rate than subjects in the decreasing condition. The same results were found after correcting for mean recall level since it was thought that clustering might be an artifact of differences in mean recall. In Experiment V, 12 subjects learned two linked lists (quartets were linked by a common word) and 12 subjects learned two comparable control lists. Each list was composed of 16 quartets which were presented in random order for three input-output cycles. Subjects with the linked lists recalled more clusters on early trials and more clusters in the order of input than the control subjects, although this advantage disappeared by the third trial. Bower et al. assumed this was because subjects were recalling from all input clusters by Trial 3. These studies are a good illustration of the importance of organization in free recall. Now we shall look at some earlier studies supporting a number of hypotheses about clustering and subjective organization.

Occurrence of Clustering

Bousfield (1953), Cohen and Bousfield (1956) and Jenkins and Russell (1952) offered evidence that subjects tend to recall randomly presented material in clusters of words. Bousfield (1953) presented subjects with a list of 60 nouns, 15 each in four categories (animals, names, professions, and vegetables). The Thorndike-Lorge tables were used to control for associative value and match the four categories in respect to frequency of occurrence. One randomization of the words was presented and the data from 100 subjects were analyzed by three

separate methods for evaluating clustering. Indices of repetition were computed by drawing randomly, without replacement, 60 colored capsules representing the four categories. A sequence was drawn for each of 100 subjects, the number drawn in each case depending upon the number of items recalled by the subject. A ratio of repetition was the ratio of the number of repetitions of items to the total items listed. The third method involved a comparison of the number of single (unclustered) items and clusters of varying sizes with chance expectations. In all three methods, artificial experimental data were compared with the actual data of subjects. It was found that subjects tended to cluster items in recall beyond a chance expectation as indicated by the parallel artificial experiment. When recall protocols were Vincentized into deciles, the clustering tendency was initially above chance, rose to a maximum in the region of the fourth decile, and dropped progressively to chance level. Degree of clustering was seen as a function of the number of items already recalled. Bousfield explained the progressive change in the clustering tendency on the basis of the concepts of habit strength and increment. Habit strength is the tendency for a response to occur, resulting from reinforcement before and during the experiment. An increment is added to individual items of a category by virtue of the subject naming an item within that category.

Cohen and Bousfield (1956) investigated the effects on clustering of a word list permitting the occurrence of clustering on two levels of organization. A dual-level word list of four categories, each with two minor categories (e.g., feline and canine animals, South American and European countries) was analyzed on two levels of organization (4 categories and 8 subcategories). Results supported the experimental

hypothesis stated by Cohen and Bousfield that the use of a dual-level list should result in stronger reinforcement of organizational systems than would be expected for comparable single-level lists. The authors found that in early stages of recall, there was more clustering in the dual-level list than in the single-level list for either four or eight categories and that the degree of clustering declined as more words were recalled. The results were interpreted in terms of Hebb's theory of superordinate perceptions. According to the theory, the recall of a word excites its superordinate system (category) which facilitates recall of other words in that category.

Jenkins and Russell (1952) investigated the clustering phenomenon in a situation in which the stimulus was produced by the subject himself rather than by the experimenter. They used a list of 48 words (24 pairs) in which the stimulus and response of each pair had high associative value. Forward association of pairs was determined by the strongest association order, according to normative data. The words were randomized for one presentation. The recall period lasted until the subjects had recalled all the words. Results supported three hypotheses. Forward and reverse association pairs appeared more frequently than arbitrarily selected pairs. Forward associations appeared more frequently than reverse association pairs. It was also found that females recalled significantly more words and produced significantly more forward associations than males. When the number of words recalled was controlled, females still recalled more forward associations than males. The results were interpreted as demonstrating that associative strength influences word clustering during recall.

Increase in Recall and Clustering Over Trials

Bousfield and Cohen (1953, 1955) and Robinson (1966) have found that recall and clustering increase over trials in multi-trial learning sessions. Bousfield and Cohen (1953) investigated the influence on clustering of varying numbers of presentations of a list of words. The list was composed of 60 two-syllable nouns, 15 each in the four categories of animals, names, professions, and vegetables. Associative values were equated by using the Thorndike-Lorge frequency tables. Five groups of subjects received one to five presentations based on five randomizations closely approximating the theoretical expectation of clustering and were then given a recall trial. The data was prepared for analysis by dividing each subject's protocol into ten deciles. The results confirmed all the predictions made by the investigators. The number of items recalled and the amount of clustering increased as the number of presentation trials increased. Progressive changes in clustering during recall were found to be a function of the number of presentation trials in the following ways: (1) The initial level of clustering was a positive function of the number of trials, i.e., the greater the number of presentation trials, the higher the level of clustering during the first decile. (2) There was a positive relationship between the number of trials and the speed of attainment of maximum clustering, i.e., the greater the number of presentation trials, the fewer deciles it took to reach the maximum level of clustering. (3) Clustering decreased for all groups as the supply of available associates approached exhaustion, i.e., the level of clustering progressively decreased in the later deciles as soon as the maximum level of

clustering was attained. The results were explained in terms of Hebb's account of the development of superordinate perceptions.

A comparable study by Bousfield and Cohen (1955) supports the results of Bousfield and Cohen (1953). The stimulus materials consisted of two lists of randomly arranged words, each list being composed of 60 nouns with 15 exemplars in each of four categories (animals, names, professions, and vegetables). One list of words had high Thorndike-Lorge frequencies-of-usage counts; the other had low Thorndike-Lorge frequencies. Each list was presented once to 75 different subjects. Again, individual protocols were divided into 10 deciles. Subjects in the high frequency group reached a higher level of clustering than subjects in the low frequency group. Progressive changes in clustering were found to be modified by frequency in the same pattern of the earlier study. Subjects presented with high frequency words exhibited a higher initial level of clustering and reached their maximum level of clustering sooner than subjects presented with low frequency words. Clustering decreased for high and low frequency subjects as the supply of available associates approached exhaustion.

Robinson (1966) deals with category clustering as opposed to item clustering and states that the mechanisms underlying category clustering are more diverse than those underlying item clustering. "In particular, association between category names should be expected to play a major role in producing what might be called second-order structure in recall." Robinson presented subjects five randomizations of a 30 item list containing ten different non-exhaustive categories. The protocols of 20 subjects who clustered perfectly on Trials 4 and 5 were used in the analysis. A category clustering index was obtained as the ratio of the number of

category pairs occurring together (in either backward or forward order) to the total number of different category pairs. Results indicated that the number of categories recalled on each trial, the number of items correctly recalled on each trial, and the amount of item clustering increased across trials. Four types of category transition processes were obtained from the analysis of linking items.

Relationship Between Clustering and Amount Recalled

A number of studies suggest a relationship between clustering and amount recalled in a free recall task (Bousfield, Cohen and Whitmarsh, 1958; Sakoda, 1956; Jenkins, Mink and Russell, 1958). Bousfield, Cohen and Whitmarsh (1958) carried out a study similar to Bousfield and Cohen (1955) but used two groups of categories: (1) Animals, names, professions, and vegetables. (2) Birds, cloths, countries, and musical instruments. Two word lists were prepared for each group of categories, one list of high frequency words, the other of low frequency words. Each of the four lists were given to a different group of subjects. Subjects exhibited significantly more clustering and recall of high frequency lists than of low frequency lists. Bousfield et al. explained the results with "the more readily subjects can categorize groups of words, the more readily will the words be recalled and the greater will be the organization of the recall."

Sakoda (1956) was concerned with Bousfield and Cohen's (1953) conclusion that clustering increased with additional presentations, implying a correlation between degree of clustering and number of words recalled and argues for the consideration of individual differences. Sakoda reanalyzed the data of Bousfield and Cohen (1953)

and found the subject's category interaction significant. Subjects did not recall and cluster words in the four different categories with equal facility. Subjects favored different categories in the first and second halves of the sequence of recall, accounting for the increase in the correlation between clustering and recall. It was concluded that taking into account sequence and individual differences, yet finding a high correlation between clustering and recall supports Bousfield and Cohen's theoretical position of superordinate structures.

Jenkins, Mink and Russell (1958) concluded that "associative clustering in recall is an increasing monotonic function of the free association strength of the pairs being recalled." Four groups of subjects were presented with four different randomized lists of 12 stimulus-response pairs, the lists ranging from low to high frequency of association for the pairs. To eliminate primacy and recency effects interfering with pairing, three experimentally unrelated words were inserted at the beginning and end of the lists. The following findings were established: (1) All groups showed a significant tendency to recall pairs together in a stimulus-response sequence. (2) The average amount of forward associative clustering was related to the average free association strength of the pairs. (3) All groups showed a significant tendency to recall pairs together in the reverse sequence. (4) There were group and sex differences, i.e., more girls were in the groups that showed the greatest clustering relative to associative strength.

Two studies (Puff, 1970 and Thompson, Hamlin and Roenker, 1972) offer contradictory evidence on the relationship between the degree of clustering and amount recalled. Puff (1970) suggested that degree of

clustering and amount recalled are not related. He prepared two categorized lists composed of three categories of ten words each, and two non-categorized lists consisted of 30 unrelated words. The lists were matched approximately in terms of the mean Thorndike-Lorge frequency. Subjects were given a practice list and one of five randomizations of an experimental list to study for a single trial. The mean number of words recalled from the two experimental lists was significantly different. The category list subjects were divided into "clusterers" and "non-clusterers" on the basis of the total number of category repetitions. Clusterers and non-clusterers did not significantly differ in the number of words they recalled from the categorized list; thus, it was concluded that degree of clustering and amount recalled were not related.

Thompson, Hamlin and Roenker (1972) took issue with Puff and devised an experiment to test Puff's conclusion. Their stimulus materials consisted of nine lists, each composed of four categories each, and each category represented by 12 exemplars. The mean frequency per category was the same for all categories. Each of three groups of subjects viewed a different set of three lists, i.e., all categories were different within a set of three lists. Three randomizations of each list were presented over three trials, and each group was subdivided such that half of a group saw one order of presentation and half of a group saw a different order of presentation. As the words were presented item-by-item, the subjects identified them according to category names which had been provided. Following each presentation was a two minute recall period in which subjects wrote down in any order the words they recalled. The authors used the

Adjusted Ratio of Clustering (ARC) to ascertain the degree of clustering relative to chance and perfect clustering. On the basis of this measure, the highest and lowest clusterers were identified from each of the six subgroups. It was found that high clusterers recalled significantly more words than low clusterers on all the three major lists, thus contradicting Puff's results. The authors discussed their opposite findings in respect to differences between the experiment and Puff's, namely, single-trial vs. multi-trial recall, the method of dividing high and low clusterers, and whole-list vs. item-by-item presentation. They speculated that Puff's list was easier to learn, which might eliminate potential differences between high and low clusterers.

Recall of Categorized vs. Non-Categorized List

There is experimental evidence that subjects recall more from a categorized list than from a non-categorized list (Wood, 1968; Underwood and Freund, 1969; Puff, 1970). The Puff (1970) study has been discussed in the previous section. An experiment by Wood (1968) supports the hypothesis that subjects given appropriate cues during the learning trial will have better recall of the early instances, i.e., the words presented first of each concept. A 3 x 2 factorial design was used, the independent variables being cue vs. no cue and number of instances (3, 5, or 8) per concept for five color concepts--black, red, green, yellow and white. Words were presented one at a time followed by colored or non-colored cues. There were eight random orders for each stimulus list; however, all the words having the same color cue appeared consecutively. All subjects were first given a non-cued recall, and it was found that cueing during learning and instances

per concept were significant effects. The interaction of cueing and instances per concept was significant for the group with eight instances per concept. All groups were cued at a second recall, but cueing during this recall had little effect on the number of additional words recalled; thus it was concluded that cueing during learning accounted for the interaction effect in the eight instances group.

Underwood and Freund (1969) performed two experiments from which they concluded that cueing during learning has a significant effect on recall. In Experiment I, a list of 40 words comprising eight instances of each of five color concepts was presented by blocked presentation to four different groups of 20 subjects. Two groups were provided with the appropriate color cues during the single learning trial. One of these cued groups was given very explicit instructions for recall. Cueing, but not explicit instructions, was found to be statistically significant in facilitating recall. The interaction effect was not significant. Generally, there was a decrease in recall as a function of the position of a word in the list, but the decrease was more marked for the cued condition since this group recalled the first words of the blocks better than the non-cued group. Cueing showed no effect on the first category presented, thus suggesting a primary effect. Experiment II tested the hypothesis that if the initial words in each block are recalled better than later words this could produce slope differences by way of successive von Restorff effects. If this were the case, the same results should be obtained when inappropriate cues are used as when appropriate colors are used. Six experimental conditions involved three cueing conditions during learning (appropriate, inappropriate, and no cues control) and two cueing conditions at recall (cued and

non-cued. The 40 item list of Experiment I was presented for a single trial; three different lists were made, all using block presentation and differing in the order in which the five concepts occurred. Only cueing during learning was found to be significant, mostly due to the lower performance of the inappropriately cued group which did not recall the first two serial positions with the facility of the appropriately cued subjects, thus not supporting the von Restorff effect hypothesis.

Subjective Organization Studies

Tulving's (1962) first experiment on subjective organization dealt with many of the issues discussed above in relation to clustering. Considering organization as a dependent variable in free recall, Tulving investigated the relationship between repetition, subjective organization, and recall. Tulving's measure of subjective organization (SO) is represented by the following formula:

$$SO = \frac{\sum_{ij} n_{ij} \log n_{ij}}{\sum_{i} n_i \log n_i}$$

SO is a ratio of maximum organization to actual organization which ranges in value from zero to 1.0. In the formula n_{ij} represents the numerical value of the cell in the i-th row and j-th column, and n_i represents the marginal total of the i-th row of a matrix in which the rows represent the n-th word and the columns represent the (n+1)th word in the subject's recall. A list of 16 two-syllable English words were arranged in 16 different sequences and presented to subjects individually for 16 trials. A memory drum was used to present the list

item-by-item, and the order in which the 16 lists were presented to the subjects was systematically counterbalanced. After each trial, the subject wrote down as many words as she could remember, in any order.

Tulving found that repetition was related to recall in the following ways: (1) Mean recall increased as a function of trials; (2) Mean subjective organization increased as a function of trials; (3) Recall and subjective organization measures were positively correlated. Tulving concluded that subjects impose a sequential structure in recalling unrelated words, that this structure or subjective organization increases with repeated exposure to and recall of the material, and that there is a systematic relationship between subjective organization and the amount recalled.

Bousfield, Puff and Cowan (1964) modified Tulving's (1962) method by applying a different statistical treatment. Subjects were presented five randomizations of ten words with zero interitem associative strength on the basis of free associational norms. Learning continued to a criterion of five consecutive errorless recalls, and was divided into three decile blocks for each trial. Statistical analysis was performed on the difference between the obtained intertrial repetitions and expected intertrial repetitions. The intertrial repetition (ITR) unit is a pair of items recalled consecutively on Trials n and n + 1. The obtained intertrial repetitions is the actual count of the number of times any pair of items occurs consecutively in recall on trials n and n + 1. The expected intertrial repetitions are represented by the formula:

$$E - ITR = \frac{(h-1)(k-1)}{w\ (\ w - 1)}$$

Where h = the number of words recalled on trial n,

k = the number of words recalled on trial n + 1,

and w = the number of stimulus words presented for recall.

It was established that the amount of subjective organization was significantly greater than chance during the three decile blocks of learning. A progressive and significant increase in subjective organization was found through the three decile blocks. The results of Bousfield et al. support those of Tulving (1962) in respect to the occurrence of subjective organization over trials. Bousfield and Bousfield (1966) modified the measure of clustering discussed above, maintaining the ITR unit. The value of the expected intertrial repetitions [E (ITR)] is less than one and calculated by the formula:

$$E\ (ITR) = \frac{[C\ (C - 1)]}{hk}$$

Where h = number of items recalled on trial n,

k = number of items recalled on trial n + 1,

and c = number of items common to trials n and n + 1.

Langhorne (1970) analyzed the effects of input order on subjective organization and recall in multi-trial free recall. Two experimental replications were carried out. In each replication a different 16-item list was presented to a different group of subjects for 16 trials, with the subjects recalling as many words as they could in any order after each trial. Within each experiment there was a constant order condition in which the input orders for the 16 trials were identical and a variable input order in which there were 16 different input orders for the 16 trials. Results indicated better recall by the constant order groups than the variable order groups. Mean recall

increased across trials for all the constant and variable order groups. A measure of organization, the intertrial organization variance (ITOV) was devised and applied to the data analysis. The ITOV is calculated by applying the Pearson product-moment correlation to items that are common to outputs on two consecutive trials and then squaring the correlation. The mean ITOV was found to be significantly higher for the constant order groups. A significant increase in organization across trials was found for the constant order groups. Increase in organization across trials in the variable order was meager by comparison. Langhorne concluded that constant input order facilitated both recall and organization of free recall material better than variable input order. The implication is that subjective organization facilitates recall, i.e., the greater the degree of organization the greater the amount of material recalled.

Proposal

The objective of the present study is to analyze the relationships of recall to clustering and subjective organization within the context of a single experiment. This has not been done heretofore. It will be accomplished by using the multitrial free recall paradigm, which is necessary to assess subjective organization, with a mixed list containing both categorized and non-categorized words. Two entirely different lists will be used. Each list will be presented in ten randomized orders to a different group of female subjects.

A comparison will be made of the recall of categorized and non-categorized words. Statistical measures will be employed to assess the degree of clustering and subjective organization. Each

measure will be applied to both categorized and non-categorized words, treating the non-categorized words as one category. The relationships between degree of clustering and amount recalled, degree of organization and amount recalled, and the degree to which clustering and organization occur in the same protocol will be studied by correlational analysis.

CHAPTER II

METHOD

Subjects

Thirty-two female college students recruited from introductory classes in psychology, biology, sociology and humanities at the University of North Dakota were subjects for the present study. Nineteen subjects received one dollar each for participating in the experiment; the remaining subjects received extra credit in their psychology classes. Two of the 32 subjects did not follow instructions and consequently were eliminated. Fifteen subjects were exposed to List ABC, and 15 subjects were exposed to List XYZ.

Apparatus

The stimulus materials consisted of the following mixed lists of 36 nouns each.

List ABC	List XYZ
1. rose	1. trout
2. tulip	2. bass
3. carnation	3. shark
4. daisy	4. herring
5. violet	5. catfish
6. orchid	6. haddock
7. lily	7. salmon

8. pansy	8. tuna
9. fly	9. robin
10. ant	10. sparrow
11. mosquito	11. bluejay
12. spider	12. eagle
13. beetle	13. crow
14. roach	14. canary
15. wasp	15. parakeet
16. ladybug	16. hawk
17. apple	17. carrot
18. orange	18. peas
19. pear	19. corn
20. banana	20. potato
21. peach	21. lettuce
22. grape	22. spinach
23. cherry	23. asparagus
24. plum	24. broccoli
25. temple	25. emerald
26. senator	26. millimeter
27. vodka	27. elephant
28. nickel	28. chapel
29. doll	29. bicycle
30. gasoline	30. scotch
31. snow	31. violin
32. decade	32. newspaper
33. knife	33. silk
34. magazine	34. tornado
35. rayon	35. lawyer
36. waltz	36. oxygen

Each list consisted of three categories of eight words each and 12 unrelated words. The categories of List ABC were flowers, insects, and fruits, the categories of List XYZ were fish, birds, and vegetables. All words, categorized and unrelated, were taken from the Battig-Montague (1969) norms. Non-exhaustive categories were selected. The eight most frequent words in the category were employed unless some special relatedness to another word in the list could be recognized, in which case a word of lower frequency was chosen. For example, "haddock" replaced "perch" because "perch" might well be associated with the birds category. The unrelated words were selected from other categories of the Battig-Montague norms such that they were comparable in frequency to the categorized words. The general procedure for selecting the non-categorized words was to find the mean frequency of the three most frequent words in each of the three categories of a list and select 12 words close in value to those three means. A randomization of the words was established, for each of the ten trial presentations, from the table of random numbers.

Procedure

A stereo tape deck and earphones were used to present the material to the subjects one at a time. Test booklets of ten pages each and pencils were supplied by the experimenter. The author was the only experimenter for the study. All instructions and materials were tape recorded at a tape speed of 3 3/4 ips. Separate tapes were made for the two lists. A single recording lasted approximately 30 minutes. A brief outline of the presented material is as follows. The subjects were given the following instructions:

> This is an experiment in memory. You will be presented a list of words for a number of trials. At the end of each presentation you are to recall as many of the words as you can remember. At the end of each trial you will hear the word RECALL. This will be your cue to begin recalling the words. Print the words you remember in the booklet before you. You may recall the words in any order. However, please print them in the order in which you remember them. Do not skip around in your printing. There should be ample time for recall following each trial. You will know a new trial is beginning when you hear the words start up again. When you hear the words begin, put your pencil down and turn the page. Remember, the object is to recall as many words as you can on every trial. Do you have any questions at this time?

At this time the experimenter turned off the tape recorder and asked the subject to repeat the instructions. When it seemed to the experimenter that the subject understood the instructions, the tape recorder was turned on again and the experiment proceeded. There were no other interruptions until the experiment was over. The subjects kept the earphones on throughout the experiment. After a 30 second pause on the tape, the first trial began at the rate of two seconds per word. At the end of each presentation a 120 second recall period was timed into the recording. At the end of the tenth recall period the following instructions were given to subjects:

> Stop writing. The experiment is over. Please do not discuss any part of the experiment with anyone. You may be talking with a potential subject, and it is important

that all subjects be treated alike in order for the results to be valid. Thank you very much for your co-operation.

The subject then took off her earphones and the experimenter explained briefly what the experiment was about.

Lists ABC and XYZ were presented to subjects 1-15 and subjects 16-30, respectively. Subject groupings were determined by order of arrival.

CHAPTER III

RESULTS

The analysis of the data began with transferring a subject's ten recall protocols by means of a coding system whereby each word in the list had a separate code (see Appendix A). After this the original protocols were only occasionally referred to and the analysis proceeded from the coded protocols. For List ABC all the flowers were coded A1-A8, the insects B1-B8, and the fruits C1-C8. The codes for non-categorized words consisted of the letter N and another letter of the alphabet. The actual codes were ND through NN and NP. For List XYZ the fish were represented by X1-X8, the birds by Y1-Y8, and the vegetables by Z1-Z8. Again, the non-categorized words were represented by N and another letter. In this case the codes were NA through NL.

Tabulations were made for the number of words recalled per category (A, B, C or X, Y Z), the number of non-categorized words recalled N, and the total recall by each subject on each trial T (see Appendix B). Subjects (rows) x trials (columns) tables were made for the recall of categorized words, Σ (A,B,C) or Σ (X,Y,Z); the recall of non-categorized words N; and the total recall scores T, represented by Tables 3, 4, and 5 respectively (see Appendix C).

The interrelationships between clustering, subjective organization, and recall are of an individual difference character. Because of this fact, it would be desirable to combine the data from the two

replications, providing that the results with the two lists are comparable. Accordingly, comparisons were made of the two replications with respect to all of the dependent variables described below. The results were similar in all respects; therefore, the two replications were combined.

Figure 1 presents the mean total recall of all 30 subjects over the ten trials. Recall increases across trials. The form of the curve is the typical negatively accelerated exponential function observed in most free recall learning studies. Its origin at first recall is at about 13 words, which is approximately 36 percent of the 36 words in the list. By the tenth trial recall is 26 words or 72 percent. There is ample learning to justify the study of clustering and subjective organization as correlates of recall.

Figure 2 compares the recall of the categorized and non-categorized words. Since there are twice as many categorized words in each list, mean percent recall by category over trials is the unit of analysis. A category effect is clearly indicated for only the first recall, $t=8.03$ ($p < 0.001$) for 29 degrees of freedom. From Trial 2 onward, there is no difference in the mean percent of words recalled.

The percentage of categorized words recalled on Trial 1 is approximately 42 percent of the 24 categorized words in the list, and the percentage of the 12 non-categorized words recalled on Trial 1 is 25 percent. On Trial 2 the percentages rise to approximately 46 percent for categorized words and 48 percent for non-categorized words. On Trial 10 the percentage of words recalled was approximately 75 percent for both categorized and non-categorized words.

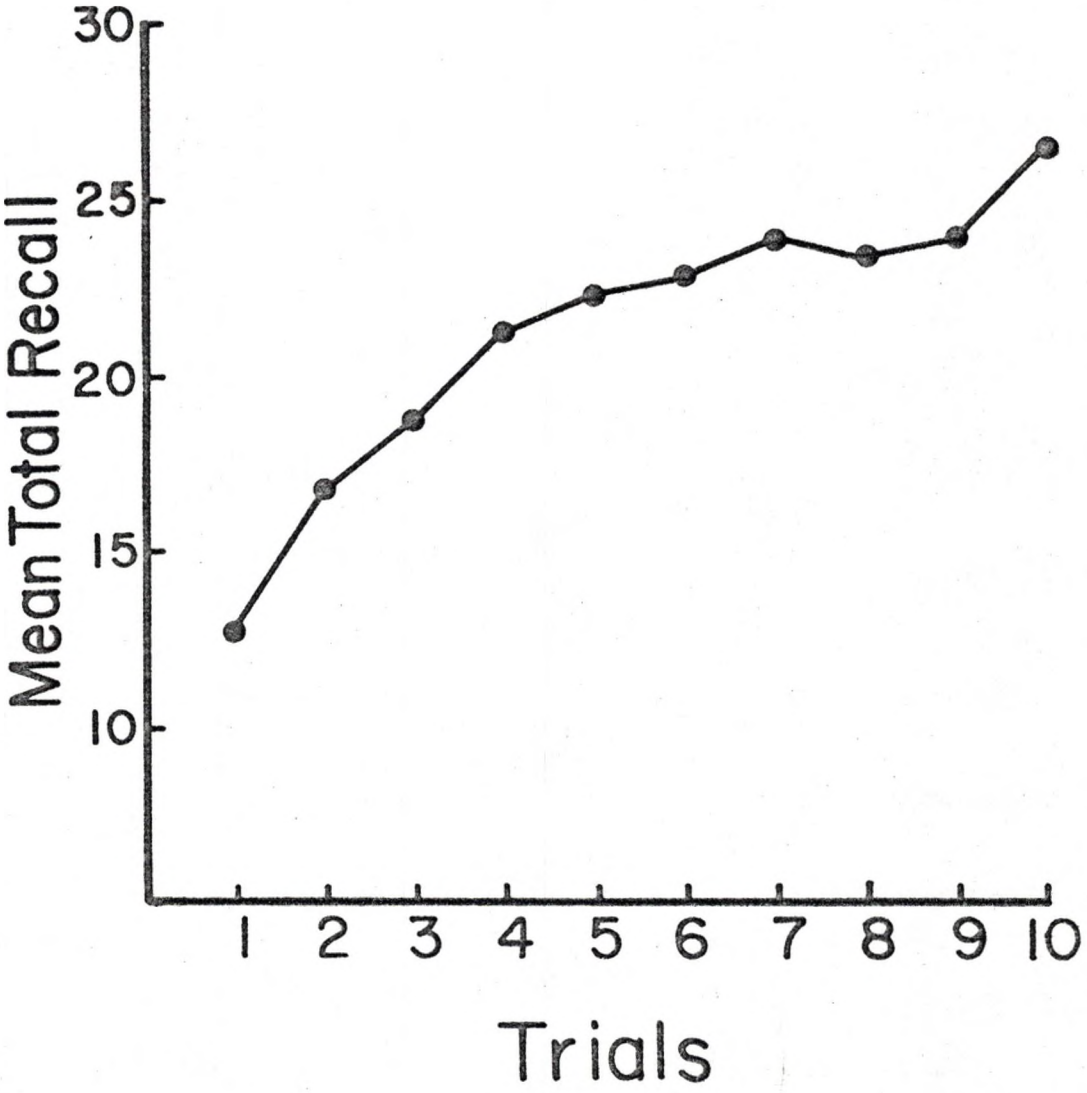
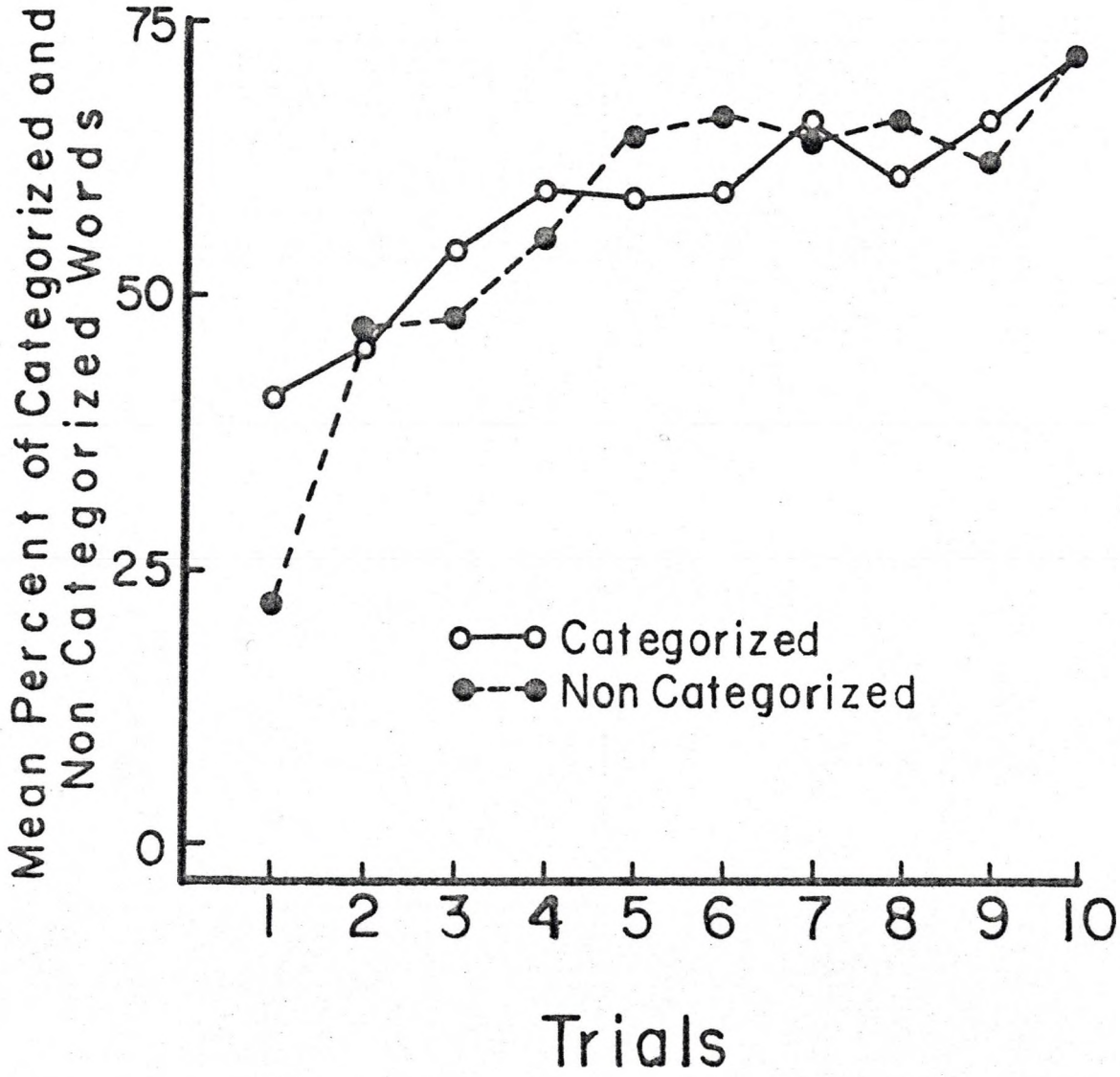

30
25
20
15
10
Mean Total Recall
1 2 3 4 5 6 7 8 9 10
Trials

Fig. 2.--Mean Percent Recall of Categorized and Non-categorized Words.


Mean Percent of Categorized and Non Categorized Words
75
50
25
0
1 2 3 4 5 6 7 8 9 10
Trials
Categorized
Non Categorized

A measure of clustering, the Adjusted Ratio of Clustering, developed by Roenker, Thompson and Brown (1971), was calculated for each protocol of each subject for a total of 300 ARC calculations. A description of the ARC measure of clustering is as follows:

$$ARC = \frac{R-E(R)}{\max R-E(R)}$$

R = total number of observed category repetitions (i.e., the number of times a category item follows an item from the same category).

max R = maximum possible number of category repetitions.

max R = N-k

where N = total number of items recalled, and

k = number of categories represented in the recall protocol.

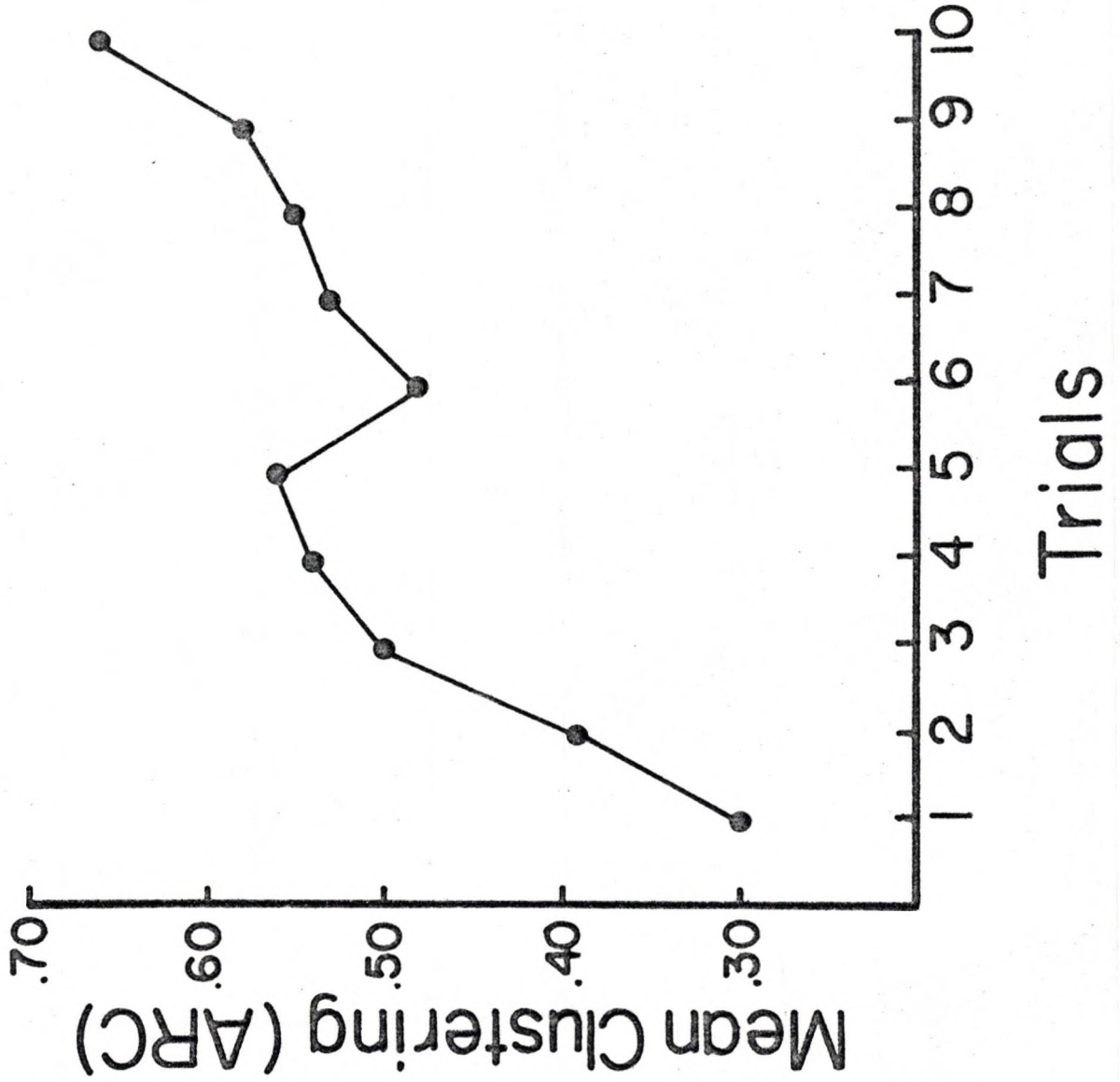
E(R) = expected (chance) number of category repetitions.

$$E(R) = \frac{\sum_i n_i^2}{N-1}$$

where n_i = number of items recalled from category i, and

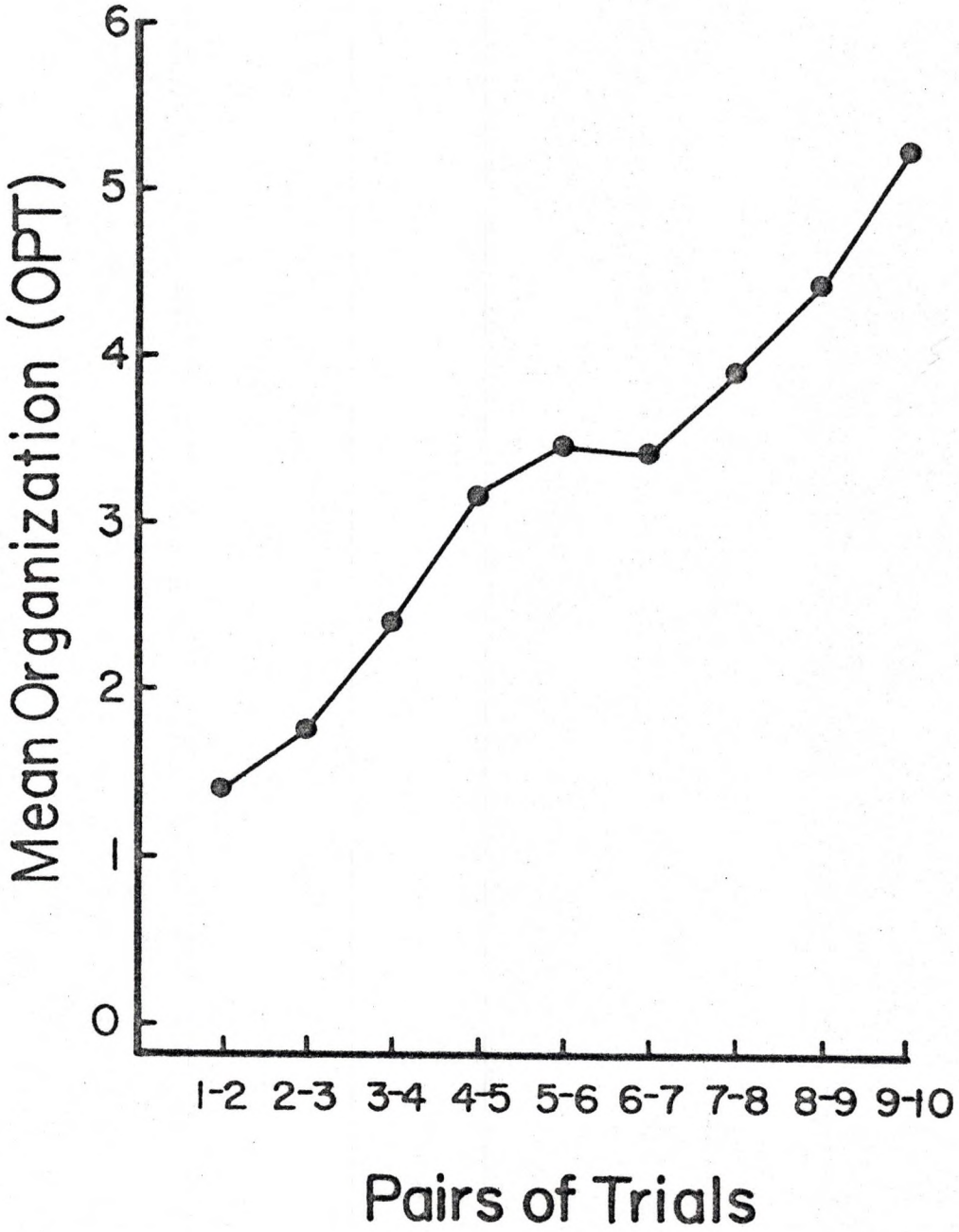
N = total number of items recalled.

Table 6 (see Appendix C) was compiled as a subjects (rows) x trials (columns) presentation of the 300 ARC values. The total and median ARC values were then plotted across trials, comparing Lists ABC and XYZ. Figure 3 represents the mean clustering (ARC) values for 30 subjects plotted across trials, illustrating an increase in clustering with the repetition of trials. The mean ARC value on Trial 1 is .30 and rises in a negatively accelerated fashion to .56


Mean Clustering (ARC)
.70
.60
.50
.40
.30
1 2 3 4 5 6 7 8 9 10
Trials

on Trial 5. The degree of clustering declines on Trial 6 to an ARC value of .48 and rises in a positively accelerated fashion to .66 on Trial 10.

A measure of organization, Organization by Pairs of Trials (OPT) was established by tabulating the number of consecutive pairs of words common to Trials 1 and 2, 2 and 3, 3 and 4, and so forth, through Trials 9 and 10. For example on subject #7's protocols, Fly and Senator occurred together on both Trials 1 and 2; therefore, the organization score for T_1-T_2 was 1. On Trials 2 and 3 the pairs Rayon-Snow and Daisy-Carnation occurred, for an organization score of 2. The T_3-R_4 organization score was 4, represented by Ladybug-Nickel-Rayon, Ant-Roach, and Daisy-Carnation occurring on both trials. Two pairs, Ladybug-Nickel and Nickel-Rayon were represented by the Ladybug-Nickel-Rayon triplet. This method is like that of Rosner (1970) who used the communicative intertrial repetition (C-ITR) which is a count of item pairs occurring sequentially on trials n and n+1 in either forward or reverse order. The traditional ITR includes only pairs of items which occur in the same order. The merits of the ITR measure are discussed in Bousfield, Puff and Cowan (1964) and Bousfield and Bousfield (1966). A subjects (rows) x trials (columns) table of the organization scores are presented in Table 7 in Appendix C. Figure 4 illustrates the mean organization scores (OPT) plotted across pairs of trials for 30 subjects. The results indicate a progressive increase in subject's organization with multi-trial exposure to the material. The mean number of word pairs recalled in either forward or reverse order on Trials 1 and 2


Mean Organization (OPT)
0
1
2
3
4
5
6
1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
Pairs of Trials

is 1.4. The OPT value rises to a mean of 5.2 word pairs recalled on Trials 9 and 10.

A correlation matrix was assembled to discover possible relationships between clustering and recall, organization and recall, and clustering and organization. Only scores on Trials 1-2, 3-4, 5-6, 7-8, 9-10 were utilized in the correlational computations. The correlation matrix is presented as Table 1. It was found that the tendency for individual subjects to cluster is related to the amount of recall. A moderate correlation, r=.43, was obtained for Trials 1 and 2. The general trend is an increase in the correlation between

TABLE 1

CORRELATION MATRIX

Trials	Clustering-Recall	Organization-Recall	Clustering Organization
1-2	.43	.28	.26
3-4	.55	.80	.52
5-6	.76	.79	.71
7-8	.66	.76	.66
9-10	.77	.83	.74

clustering and recall to a moderately high correlation, r=.77, on Trials 9 and 10. Organization and recall were found to be highly correlated. Very little organization was found in the beginning trials and the correlation coefficient for Trials 1 and 2 was low, r=.28. The correlation coefficient rose to r=.80 on Trials 3 and 4 and was r=.83 on Trials 9 and 10. The correlation value for clustering and organization

was again low for Trials 1 and 2, but clustering and organization were found to be moderately related on Trials 3 and 4, r=.52. The pattern of the correlations between clustering and organization is much like that between clustering and recall, rising to an r value of .74 on Trials 9 and 10. In summary, the correlation values for all three comparisons increase over trials.

CHAPTER IV

DISCUSSION

The one trial category effect found in the present study is contrary to what might be expected on the basis of previous studies in which categorized words were recalled with more facility than non-categorized words (Puff, 1970). Most previous studies have been of the single trial variety, and therefore do not contradict results of the present study. However, Koeppel and Beecroft (1967) found a category effect for more than one trial. Perhaps aural presentation by tape recorder made a difference. Subjects may have learned quickly to take advantage of the recency effect; they may have emptied their short-term auditory store without regard for whether the words were categorized or non-categorized. For the present study it was advantageous that the category effect did not last since the clustering and subjective organization measures were applied to both categorized and non-categorized words. The results are consequently much clearer.

An increase in clustering across trials corroborates the work of Bousfield and Cohen (1953, 1955) and Robinson (1966). The decline in the degree of clustering on Trial 6 is not found elsewhere in the literature. This effect is probably of no real significance. Since the effect was found for both lists and both lists were presented according to the same randomization orders, perhaps the Trial 6 randomization was such that it may have interfered with clustering. There seems to be no

other logical explanation for the effect. The increase in organization scores across trials supports the results obtained by Tulving (1962), Bousfield, Puff and Cowan (1964) and Langhorne (1970) and was a much expected result.

The correlation matrix is of interest to the present study because the author has not found such an analysis in the literature on free recall studies. Investigators have inferred a relationship between the degree of clustering and amount recalled on the basis of the finding that both clustering and recall increase over repeated presentations, either before or during the experimental session (Bousfield, Cohen and Whitmarsh, 1958; Jenkins, Mink and Russell, 1958; and Thompson, Hamlin and Roenker, 1972). Sakoda (1956) expressed concern over such conclusions. Weingartner (1964) found a significant correlation, $r=.40$ ($p < 0.01$) between clustering tendency and the total number of words correctly recalled for a two category list presented for one trial. Weingartner's correlation, $r=.40$, is comparable to the $r=.43$ found for Trials 1 and 2 in the present study.

The correlational figures presented in this study support the conclusions of the above mentioned investigators and indicate a strong relationship between degree of clustering and total recall. Puff (1970), using a one-trial method of investigation, concluded that there was no relationship between clustering and recall. However, Puff's experiment was not a correlational study. He divided subjects into "clusterers" and "non-clusterers" and compared the total recall for the two groups. Also, Puff used a whole list presentation method rather than the item-by-item presentation of the present study. Perhaps these differences in experimental procedure account for Puff's opposite findings.

The correlations found between organization and recall are not surprising in light of correlations computed by Tulving (1962, 1964), and Langhorne's (1970) investigations. Tulving (1964) presented 32 subjects with 22 items for 22 trials. He tabulated recall scores over blocks of trials and computed correlations between subjective organization (SO) and recall. The correlation coefficient was .51 for Trials 2-8, .72 for Trials 9-15, and .84 for Trials 16-22. Using a 16-item list for 16 presentations, Tulving (1962) found correlation coefficients of .45 and .78 between subjective organization (SO) and recall over Trials 1-8 and 9-16, respectively, and an overall correlation of .63. In both studies, Tulving's data indicates an increase in the relationship between subjective organization and recall with repeated presentations of the material. Such an increase was also found in the present study. Although Tulving used a wider range of blocks of trials, fewer items and more trials, than in the present study, his results are very similar to the present author's findings.

Tulving (1966) carried out a series of experiments in an attempt to explain the observed correlations between subjective organization and number of words recalled. In two experiments, the mere repetition of list-items on reading trials had no effect on the recall of the items during an immediately following recall period. Two other experiments demonstrated that learning a whole list of items by free recall procedures is impaired by subjects learning half of the items prior to learning the whole list. Tulving offers these findings as evidence that organization determines the increase in recall, rather than organization being a mere artifact of the increase in recall resulting from practice with the material.

According to the literature on free recall studies it appears that no other investigators have studied the relationship between clustering and subjective organization. The present finding of moderately high correlations between clustering and organization is very significant in that respect. It should be noted that clustering and subjective organization have been assessed by different procedures, yet there is apparently a great deal of overlap between them.

APPENDIX A

EXPERIMENTAL LISTS AND CODES

Experimental Lists and Codes

List ABC		List XYZ	
rose	A1	trout	X1
tulip	A2	bass	X2
carnation	A3	shark	X3
daisy	A4	herring	X4
violet	A5	catfish	X5
orchid	A6	haddock	X6
lily	A7	salmon	X7
pansy	A8	tuna	X8
fly	B1	tobin	Y1
ant	B2	sparrow	Y2
mosquito	B3	bluejay	Y3
spider	B4	eagle	Y4
beetle	B5	crow	Y5
roach	B6	canary	Y6
wasp	B7	parakeet	Y7
ladybug	B8	hawk	Y8
apple	C1	carrot	Z1
orange	C2	peas	Z2
pear	C3	corn	Z3
banana	C4	potato	Z4
peach	C5	lettuce	Z5
grape	C6	spinach	Z6
cherry	C7	asparagus	Z7
plum	C8	broccoli	Z8

temple	ND
senator	NE
vodka	NF
nickel	NG
doll	NH
gasoline	NI
snow	NJ
decade	NK
knife	NL
magazine	NM
rayon	NN
waltz	NP

emerald	NA
millimeter	NB
elephant	NC
chapel	ND
bicycle	NE
scotch	NF
violin	NG
newspaper	NH
silk	NI
tornado	NJ
lawyer	NK
oxygen	NL

APPENDIX B

ANALYSIS OF RECALL

TABLE 2

ANALYSIS OF RECALL

		Trials									
		1	2	3	4	5	6	7	8	9	10
Subjects											
1	T	15	17	24	28	23	32	28	29	30	32
	A	2	5	7	7	7	7	7	7	7	8
	B	4	4	6	7	8	8	7	7	7	8
	C	5	5	5	6	0	8	8	8	7	8
	N	4	3	6	8	8	9	6	7	9	8
2	T	10	12	16	22	26	24	29	27	28	31
	A	3	3	4	5	6	7	7	6	6	8
	B	5	3	3	4	6	0	5	7	6	5
	C	0	2	2	5	5	6	7	6	5	7
	N	2	4	7	8	9	11	10	8	10	11
3	T	12	18	16	22	19	19	23	22	21	22
	A	3	3	4	5	4	4	4	4	3	3
	B	4	6	3	5	4	3	4	4	5	6
	C	2	4	5	4	4	5	5	5	6	5
	N	3	5	4	8	7	7	10	9	7	8
4	T	12	18	14	12	20	12	16	12	15	16
	A	4	4	3	5	4	4	1	3	3	2
	B	3	2	4	4	3	0	6	2	3	4
	C	2	5	1	0	6	2	4	0	4	6
	N	3	7	6	3	7	6	5	7	5	4
5	T	8	13	17	24	25	30	28	31	29	29
	A	3	0	4	5	6	7	6	7	7	7
	B	1	3	4	5	5	6	7	8	7	6
	C	3	6	5	6	6	7	7	7	8	7
	N	1	4	4	8	8	10	8	9	7	9
6	T	18	19	22	26	28	28	28	30	26	31
	A	5	4	6	7	6	6	6	7	5	8
	B	4	3	4	4	5	6	6	7	6	7
	C	5	3	5	5	6	7	4	5	4	6
	N	4	9	7	10	11	9	12	11	11	10
7	T	18	22	21	23	26	20	21	24	24	30
	A	3	3	4	4	4	3	4	6	4	7
	B	7	4	8	3	6	6	6	8	7	7
	C	4	6	4	5	7	4	4	5	7	7
	N	4	9	5	11	9	7	7	5	6	9

TABLE 2--Continued

Subjects		Trials 1	2	3	4	5	6	7	8	9	10
8	T	14	24	26	30	28	31	34	33	33	35
	A	2	5	7	8	7	7	7	7	7	7
	B	3	5	6	7	6	7	8	8	7	8
	C	5	6	5	5	7	7	8	7	8	8
	N	4	8	8	10	8	10	11	11	11	12
9	T	10	20	25	26	28	28	31	31	33	33
	A	3	4	6	5	6	6	7	7	7	8
	B	0	4	6	7	6	5	7	7	8	7
	C	4	7	7	7	7	7	7	7	7	7
	N	3	5	6	7	9	10	10	10	11	12
10	T	9	15	17	20	19	21	21	15	23	20
	A	4	3	4	7	6	5	5	3	5	3
	B	3	5	5	4	5	3	3	2	5	6
	C	0	2	4	5	1	5	5	4	6	5
	N	2	5	4	4	7	8	8	6	7	6
11	T	10	13	15	21	23	16	16	17	14	22
	A	2	3	2	5	4	1	2	4	4	4
	B	2	2	3	6	4	4	4	4	4	6
	C	4	1	5	3	6	6	3	3	2	5
	N	2	7	5	7	9	5	7	6	4	7
12	T	9	15	17	19	23	23	22	27	24	25
	A	1	3	3	5	6	5	4	4	5	5
	B	2	3	4	4	5	6	4	7	4	5
	C	4	4	6	4	5	4	8	8	5	8
	N	2	5	4	6	7	8	6	8	10	7
13	T	11	15	17	15	17	18	21	21	14	20
	A	3	2	3	4	4	5	4	3	3	2
	B	0	4	4	4	3	2	5	5	5	5
	C	4	4	4	4	3	3	4	3	1	5
	N	4	5	6	3	7	8	8	10	5	8
14	T	14	27	21	19	24	22	25	22	23	28
	A	5	6	6	3	6	3	5	4	6	4
	B	3	6	5	4	6	5	6	5	5	8
	C	3	7	4	5	2	6	5	5	7	7
	N	3	8	6	7	10	8	9	8	5	9

TABLE 2--Continued

		Trials									
		1	2	3	4	5	6	7	8	9	10
Subjects											
15	T	9	16	17	19	13	17	21	16	22	22
	A	3	2	4	5	2	3	5	1	5	3
	B	3	3	3	3	4	5	6	5	5	6
	C	2	5	4	5	2	5	6	2	4	5
	N	1	6	6	6	5	4	4	8	8	8
16	T	15	17	18	17	17	22	21	20	19	20
	X	6	3	4	4	4	3	3	3	3	4
	Y	3	3	4	6	4	6	4	3	6	3
	Z	3	5	4	3	4	6	6	6	4	6
	N	3	6	6	4	5	7	8	8	6	7
17	T	19	14	19	20	17	23	19	19	23	22
	X	4	2	3	5	3	4	4	4	4	3
	Y	3	2	3	3	3	4	1	5	4	4
	Z	4	2	3	4	4	5	6	1	5	4
	N	8	8	10	8	7	10	8	9	10	11
18	T	10	11	16	21	22	20	22	20	24	26
	X	2	3	0	4	4	3	4	6	6	6
	Y	3	3	5	4	6	3	6	4	7	6
	Z	3	3	4	6	4	5	3	2	4	5
	N	2	2	7	7	8	9	9	8	6	9
19	T	17	16	21	25	28	25	30	29	31	34
	X	5	2	4	5	5	6	6	6	7	7
	Y	5	4	3	6	7	5	7	6	8	7
	Z	4	3	6	6	6	6	8	7	7	8
	N	3	7	8	8	10	8	9	10	9	12
20	T	17	17	21	26	24	21	27	25	22	25
	X	3	4	4	6	5	5	7	5	4	4
	Y	4	3	6	7	5	5	6	5	5	6
	Z	5	4	4	6	5	5	7	5	6	6
	N	5	6	7	7	9	6	7	10	7	9
21	T	14	16	15	17	19	12	14	15	18	23
	X	2	3	3	4	6	2	2	4	1	5
	Y	3	2	1	3	3	1	4	3	5	5
	Z	5	5	5	3	4	1	3	5	6	6
	N	4	6	6	7	6	8	5	3	6	7

TABLE 2--Continued

		Trials									
		1	2	3	4	5	6	7	8	9	10
Subjects											
22	T	10	13	14	16	16	18	19	11	15	19
	X	2	4	2	6	3	5	5	0	3	3
	Y	2	1	4	2	2	1	3	4	1	4
	Z	4	3	3	5	5	4	6	3	5	4
	N	2	5	5	3	6	8	5	4	6	8
23	T	14	21	23	24	29	29	29	32	28	33
	X	4	5	5	6	6	5	6	7	6	7
	Y	3	5	5	6	7	8	6	7	7	8
	Z	6	5	5	4	6	8	7	7	7	7
	N	1	6	8	8	10	8	10	11	8	11
24	T	11	16	19	21	23	24	26	23	28	29
	X	2	1	4	3	4	4	7	5	6	7
	Y	2	4	3	5	6	7	4	5	6	7
	Z	5	6	6	6	5	6	6	6	6	6
	N	2	5	6	7	8	7	9	7	10	9
25	T	11	18	15	19	18	20	21	23	25	28
	X	4	3	4	5	0	5	5	5	6	6
	Y	2	3	5	6	5	5	5	6	6	7
	Z	4	6	3	4	6	5	6	6	7	7
	N	1	6	3	4	7	5	5	6	6	8
26	T	10	13	15	15	12	20	15	16	16	19
	X	2	1	3	3	4	1	2	2	3	4
	Y	3	5	5	6	2	7	2	2	3	4
	Z	4	4	5	3	2	6	5	6	5	5
	N	1	3	2	3	4	6	6	6	5	6
27	T	18	21	23	26	30	29	29	31	30	32
	X	4	4	6	5	5	6	7	6	7	7
	Y	5	6	6	5	7	6	6	6	5	6
	Z	5	5	6	6	8	6	6	7	6	7
	N	4	6	5	10	10	11	10	12	12	12
28	T	10	16	20	21	22	21	22	23	24	23
	X	0	4	3	5	3	2	4	4	5	3
	Y	4	4	5	6	5	5	6	6	7	7
	Z	3	3	6	3	6	3	6	5	6	5
	N	3	5	6	7	8	11	6	8	6	8

TABLE 2--Continued

		Trials									
		1	2	3	4	5	6	7	8	9	10
Subjects											
29	T	10	13	17	20	20	24	27	23	23	28
	X	3	3	2	3	4	6	6	5	4	6
	Y	2	2	4	5	3	4	5	4	6	7
	Z	5	4	5	5	5	5	7	4	7	7
	N	0	4	6	7	8	9	9	9	6	8
30	T	15	19	24	24	27	29	29	29	31	33
	X	4	4	6	6	7	8	7	8	8	8
	Y	5	4	6	5	5	5	6	5	6	6
	Z	5	6	5	6	6	7	8	7	6	7
	N	1	5	7	7	9	9	8	9	11	12

APPENDIX C

ANALYSIS OF RECALL, CLUSTERING AND SUBJECTIVE ORGANIZATION

TABLE 3

RECALL OF CATEGORIZED WORDS

Subjects	Trials 1	2	3	4	5	6	7	8	9	10
1	11	14	18	20	15	23	22	22	21	24
2	8	8	9	14	17	13	19	19	17	20
3	9	13	12	14	12	12	13	13	14	14
4	9	11	8	9	13	6	11	5	10	12
5	7	9	13	16	17	20	20	22	22	20
6	14	10	15	16	17	19	16	19	15	21
7	14	13	16	12	17	13	14	19	18	21
8	10	16	18	20	20	21	23	22	22	23
9	7	15	19	19	19	18	21	21	22	22
10	7	10	13	16	12	13	13	9	16	14
11	8	6	10	14	14	11	9	11	10	15
12	7	10	13	13	16	15	16	19	14	18
13	7	10	11	12	10	10	13	11	9	12
14	11	19	15	12	14	14	16	14	18	19
15	8	10	11	13	8	13	17	8	14	14
16	12	11	12	13	12	15	13	12	13	13
17	11	6	9	12	10	13	11	10	13	11
18	8	9	9	14	14	11	13	12	18	17
19	14	9	13	17	18	17	21	19	22	22
20	12	11	14	19	15	15	20	15	15	16
21	10	10	9	10	13	4	9	12	12	16
22	8	8	9	13	10	10	14	7	9	11
23	13	15	15	16	19	21	19	21	20	22
24	9	11	13	14	15	17	17	16	18	20
25	10	12	12	15	11	15	16	17	19	20
26	9	10	13	12	8	14	9	10	11	13
27	14	15	18	16	20	18	19	19	18	20
28	7	11	14	14	14	10	16	15	18	15
29	10	9	11	13	12	15	18	13	17	20
30	14	14	17	17	18	20	21	20	20	21
Totals	298	335	389	435	430	436	479	452	485	426

TABLE 4

RECALL OF NON-CATEGORIZED WORDS

Subjects	Trials 1	2	3	4	5	6	7	8	9	10
1	4	3	6	8	8	9	6	7	9	8
2	2	4	7	8	9	11	10	8	10	11
3	3	5	4	8	7	7	10	9	7	8
4	3	7	6	3	7	6	5	7	5	4
5	1	4	4	8	8	10	8	9	7	9
6	4	9	7	10	11	9	12	11	11	10
7	4	9	5	11	9	7	7	5	6	9
8	4	8	8	10	8	10	11	11	11	12
9	3	5	6	7	9	10	10	10	11	12
10	2	5	4	4	7	8	8	6	7	6
11	2	7	5	7	9	5	7	6	4	7
12	2	5	4	6	7	8	6	8	10	7
13	4	5	6	3	7	8	8	10	5	8
14	3	8	6	7	10	8	9	8	5	9
15	1	6	6	6	5	4	4	8	8	8
16	3	6	6	4	5	7	8	8	6	7
17	8	8	10	8	7	10	8	9	10	11
18	2	2	7	7	8	9	9	8	6	9
19	3	7	8	8	10	8	9	10	9	12
20	5	6	7	7	9	6	7	10	7	9
21	4	6	6	7	6	8	5	3	6	7
22	2	5	5	3	6	8	5	4	6	8
23	1	6	8	8	10	8	10	11	8	11
24	2	5	6	7	8	7	9	7	10	9
25	1	6	3	4	7	5	5	6	6	8
26	1	3	2	3	4	6	6	6	5	6
27	4	6	5	10	10	11	10	12	12	12
28	3	5	6	7	8	11	6	8	6	8
29	0	4	6	7	8	9	9	9	6	8
30	1	5	7	7	9	9	8	9	11	12
Totals	82	170	176	203	236	242	235	243	230	265

TABLE 5

TOTAL RECALL SCORES

Subjects	Trials 1	2	3	4	5	6	7	8	9	10
1	15	17	24	28	23	32	28	29	30	32
2	10	12	16	22	26	24	29	27	28	31
3	12	18	16	22	19	19	23	22	21	22
4	12	18	14	12	20	12	16	12	15	16
5	8	13	17	24	25	30	28	31	29	29
6	18	19	22	26	28	28	28	30	26	31
7	18	22	21	23	26	20	21	24	24	30
8	14	24	26	30	28	31	34	33	33	35
9	10	20	25	26	28	28	31	31	33	34
10	9	15	17	20	19	21	21	15	23	20
11	10	13	15	21	23	16	16	17	14	22
12	9	15	17	19	23	23	22	27	24	25
13	11	15	17	15	17	18	21	21	14	20
14	14	27	21	19	24	22	25	22	23	28
15	9	16	17	19	13	17	21	16	22	22
16	15	17	18	17	17	22	21	20	19	20
17	19	14	19	20	17	23	19	19	23	22
18	10	11	16	21	22	20	22	20	24	26
19	17	16	21	25	28	25	30	29	31	34
20	17	17	21	26	24	21	27	25	22	25
21	14	16	15	17	19	12	14	15	18	23
22	10	13	14	16	16	18	19	11	15	19
23	14	21	23	24	29	29	29	32	28	33
24	11	16	19	21	23	24	26	23	28	29
25	11	18	15	19	18	20	21	23	25	28
26	10	13	15	15	12	20	15	16	16	19
27	18	21	23	26	30	29	29	31	30	32
28	10	16	20	21	22	21	22	23	24	23
29	10	13	17	20	20	24	27	23	23	28
30	15	19	24	24	27	29	29	29	31	33
Totals	380	505	565	638	666	678	714	696	716	791

TABLE 6

ADJUSTED RATIO OF CLUSTERING

Subjects	Trials 1	2	3	4	5	6	7	8	9	10
1	.49	.89	.86	.88	.92	.85	.72	.89	.84	.95
2	.28	.48	.13	.69	.56	.47	.72	.53	.94	.69
3	.14	.21	.54	.23	.71	-.01	-.06	.05	.59	.38
4	.48	-.02	.24	.65	.47	.06	.26	-.03	.13	.41
5	-.60	-.15	.27	.45	.80	.68	.72	.55	.62	.62
6	.33	.19	.32	.17	.30	.60	.42	.52	.67	.49
7	.50	.52	.10	.44	.75	.47	.59	.79	.52	.79
8	.44	.72	.87	.89	.94	1.00	.91	.95	1.00	1.00
9	.13	.82	.80	.63	.88	.94	1.00	1.00	1.00	.91
10	.47	.10	.79	.91	.40	.25	.42	.47	.78	.91
11	.76	.22	.10	.59	.85	.38	.01	.68	.58	.62
12	.38	.38	.36	.36	.64	.42	.53	.76	.64	.93
13	.24	.00	.15	.51	.56	.25	.26	.55	-.04	.27
14	-.23	.70	.20	.62	.63	.38	.54	.31	.72	.60
15	-.15	.76	.68	.36	-.28	.37	.68	.85	.84	.76
16	.23	.46	.51	.26	.07	.61	.17	.36	.44	.65
17	.42	-.07	.46	-.06	-.09	-.06	.28	.58	.24	.57
18	-.13	.80	.64	.83	.61	.16	.28	.45	.28	.50
19	.47	.38	.58	.67	.60	.74	.79	.67	.85	.86
20	.79	.47	.67	.87	.58	.68	.76	.53	.69	.73
21	.16	-.19	.17	.56	.35	.05	.16	.62	.26	.64
22	.29	.18	.30	.40	.40	.34	.73	.24	-.10	.14
23	.24	.76	.78	.52	.89	.78	.73	.71	.78	.81
24	.13	.26	.63	.67	.49	.45	.62	.71	.88	.73
25	.13	.70	.87	.63	.79	.91	1.00	.71	.93	1.00
26	.50	.17	.36	.36	.47	.36	.32	.00	.20	.28
27	.81	.84	1.00	.87	1.00	.94	1.00	1.00	1.00	1.00
28	.13	.32	.49	.27	.54	.14	.40	.06	.20	.34
29	.76	.08	.35	.22	.20	.31	.17	.29	.29	.39
30	.60	1.00	1.00	1.00	.88	.89	.89	.89	.90	.91
Totals	9.19	11.98	15.22	16.45	16.91	14.41	16.02	16.69	17.67	19.88

TABLE 7

ORGANIZATION BY PAIRS OF TRIALS

Subjects	Pairs of Trials 1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	2	3	5	3	6	3	8	8	5
2	0	0	1	5	5	5	5	7	6
3	2	2	0	0	1	2	4	2	6
4	0	0	1	1	0	0	0	2	0
5	1	0	4	3	7	11	10	5	7
6	1	2	7	3	5	1	3	6	10
7	1	2	4	4	2	0	5	4	7
8	0	3	6	6	7	10	9	8	10
9	0	2	4	4	9	7	9	11	11
10	1	3	1	3	1	4	4	2	5
11	0	1	1	2	3	1	1	1	2
12	2	0	0	3	1	1	7	5	3
13	3	2	1	2	0	0	0	1	0
14	1	1	1	2	0	1	1	3	5
15	0	3	2	0	2	2	2	4	3
16	1	2	1	1	1	3	2	2	1
17	2	0	2	2	2	1	1	4	3
18	2	1	3	5	2	1	3	2	2
19	3	1	3	5	2	5	1	6	5
20	4	0	5	4	5	3	5	3	5
21	2	1	0	2	2	0	1	1	2
22	0	2	0	2	0	0	0	0	1
23	1	7	3	5	10	9	8	8	11
24	2	1	4	4	5	7	3	5	8
25	1	2	2	2	4	4	3	4	8
26	1	1	0	1	1	1	1	0	1
27	4	3	3	8	10	7	10	10	14
28	1	2	1	2	2	1	4	2	1
29	1	2	0	3	4	3	1	0	5
30	3	4	7	8	5	9	6	16	9
Totals	42	53	72	95	104	102	117	132	156

REFERENCES

REFERENCES

Battig, W. F., & Montague, W. E. Category norms for verbal items in 56 categories. A replication and extension of the Connecticut Category Norms. Journal of Experimental Psychology, 1969, 30 (3, Pt. 2).

Bousfield, A. K., & Bousfield, W. A. The measurement of clustering and of sequential constancies in repeated free recall. Psychological Reports, 1966, 19, 935-942.

Bousfield, W. A. The occurrence of clustering in the recall of randomly arranged associates. Journal of General Psychology, 1953, 49, 229-240.

Bousfield, W. A., & Cohen, B. H. The effects of reinforcement on the occurrence of clustering in the recall of randomly arranged associates. Journal of Psychology, 1953, 36, 67-81.

Bousfield, W. A., & Cohen, B. H. The occurrence of clustering in the recall of randomly arranged words of different frequencies-of-usage. Journal of General Psychology, 1955, 52, 83-95.

Bousfield, W. A., Cohen, B. H., & Whitmarsh, G. A. Associative clustering in the recall of words of different taxonomic frequencies of occurrence. Psychological Reports, 1958, 4, 39-44.

Bousfield, W. A., Puff, C., and Cowan, T. The development of constancies in sequential organization during repeated free recall. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 449-459.

Bower, G. H., Lesgold, A. M., & Tieman, D. Grouping operations in free recall. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 481-493.

Cofer, C. N. Does conceptual organization influence the amount retained in immediate free recall? In B. J. Kleinmuntz (Ed.), Concepts and the structure of memory. New York: Wiley, 1967.

Cohen, B. H., & Bousfield, W. A. The effects of a dual-level stimulus word list on the occurrence of clustering in recall. Journal of General Psychology, 1956, 55, 51-58.

Jenkins, J. J., Mink, W. D., & Russell, W. A. Associative clustering as a function of verbal association strength. Psychological Reports, 1958, 4, 127-136.

Jenkins, J. J., & Russell, W. A. Associative clustering during recall. Journal of Abnormal and Social Psychology, 1952, 47, 818-821.

Koeppel, J. C., & Beecroft, R. S. The conceptual similarity effect in free recall. Psychonomic Science, 1967, 9, 213-214.

Langhorne, J. E. Input order, subjective organization and free recall. Unpublished Ph.D. dissertation, University of North Dakota, 1970.

Mandler, G. Organization and memory. In K. W. Spence and J. A. Spence (Eds.), The psychology of learning and motivation. Vol. 1. New York: Academic Press, 1967.

Puff, C. R. Role of clustering in free recall. Journal of Experimental Psychology, 1970, 86, 384-386.

Robinson, J. A. Category clustering in free recall. Journal of Psychology, 1966, 62, 279-285.

Roenker, D. L., Thompson, C. P., & Brown, S. C. Comparison of measures for the estimation of clustering in free recall. Psychological Bulletin, 1971, 76, 45-48.

Rosner, S. R. The effects of presentation and recall trials on organization in multitrial free recall. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 69-74.

Sakoda, J. M. Individual differences in correlation between clustering and recall of meaningful words. Journal of General Psychology, 1956, 54, 183-190.

Thompson, C. P., Hamlin, V. J., and Roenker, D. L. A comment on the role of clustering in free recall. Journal of Experimental Psychology, 1972, 94, 108-109.

Tulving, E. Subjective organization in free recall of "unrelated" words. Psychological Review, 1962, 69, 344-354.

Tulving, E. Intratrial and intertrial retention: Notes toward a theory of free recall verbal learning. Psychological Review, 1964, 71, 219-237.

Tulving, E. Subjective organization and effects of repetition in multitrial free-recall learning. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 193-197.

Tulving, E. Theoretical issues in free recall. In T. R. Dixon and D. L. Horton (Eds.), Verbal behavior and general behavior theory. Englewood Cliffs, N. J.: Prentice-Hall, 1968.

Underwood, B. J., & Freund, J. S. Further studies on conceptual similarity in free recall learning. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 30-35.

Weingartner, H. The free recall of sets of associatively related words. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 6-10.

Wood, G. Implicit responses and conceptual similarity: A repetition. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 838-840.