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The University of Michigan, Ph.D., 1975
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DEVELOPMENTAL CHANGES IN CHILDREN'S USE OF ORGANIZATION IN RECALL

by

Robert Hubert Jongeward, Jr.

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Psychology)
in The University of Michigan
1975

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ACKNOWLEDGEMENTS

Important contributions were made by several individuals during the planning and execution of this research. The members of my doctoral committee, Drs. John Hagen, Harold Stevenson, Robert Pachella and Wilfred Kincaid, provided many helpful criticisms and suggestions. Robert Kail provided valuable assistance in the preparation of stimuli and in several of the data analyses.

I would also like to thank Drs. Robert Bjork and John Hagen for their guidance during my entire graduate career.

The enthusiastic cooperation of Barbara Donahue, principal, and the staff and students of St. Francis Elementary School, Ann Arbor, Michigan, is greatly appreciated.

Finally, I would like to thank my wife, Barbara, for her help in several phases of this research and for her understanding support during my years as a graduate student.

PREFACE

This research was completed while the author was supported by a United States Public Health Service Developmental Training Grant, Grant No. 5 T01 HD 00149-08.

The research was funded by a grant from the National Student Dissertation Grant, administered by the Horace H. Rackham Graduate Student Research Fund.

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CHAPTER I

INTRODUCTION

It is generally believed that there exists a limit to the number of unrelated items a subject can recall during a single trial in a free recall experiment (Miller, 1956 and Mandler, 1967). Yet, in studies with both adults and children, it has been found that the number of words a subject recalls generally exceeds this limit. Several theorists (e.g., Mandler, 1967 and Tulving, 1968) have invoked Miller's (1956) "chunking" hypothesis to explain this phenomenon. They suggest that subjects reorganize the individual words into groups that are related in some way. A distinction must then be made between nominal units (the individual items) and functional units (the higher-order units formed by the subject) in memory. Thus, while the number of nominal units recalled may exceed the limitations of short-term memory, the number of functional units does not.

Processes responsible for this reorganization in memory have received considerable attention (for example, see Tulving & Donaldson, 1972). The free recall paradigm is ideally suited for this type of research because the subject is permitted to recall the words in any order he wishes. Typically, it is found that subjects produce their responses at the time of recall in an order that differs from the presentation order. Consistent discrepancies between input and output orders are used as evidence of the organization subjects impose on their recall.

Tulving (1968) has made a distinction between two types of organization. Primary organization refers to consistent discrepancies between input and output orders that are not dependent upon the subject's prior familiarity with the stimulus materials. A common example is the recency effect, the tendency for subjects to recall the last items presented in a list before earlier items. In contrast, secondary organization refers to input-output order discrepancies that are dependent upon the semantic, associative or phonetic relations among the items and upon the subject's pre-experimental knowledge of those relations. It is this second type of organization that is of interest here.

One method of investigating secondary organization is to present lists consisting of subsets of words that are associatively or conceptually related (i.e., categories). Although the presentation order of the words is determined randomly, numerous investigators (Bousfield, 1953; Bousfield & Cohen, 1955; Cohen, 1963; Jenkins & Russel, 1952; and Deese, 1959) have found that adults tend to recall related words together and that this "clustering" is greater than would be expected by chance. (Shuell, 1969, reviews the various measures of clustering that have been developed as indices of organization.) Furthermore, recall of these lists generally is higher than for comparable lists consisting of unrelated words and the level of recall is often related to the level of clustering.

Recently, there has been a good deal of interest in organizational processes in children's recall. The original impetus for these studies

was the notion that children's performance would be less affected by the presence of categories in recall lists because their experience with words, and the relations among words, was less. Now, however, this research is of interest primarily because it reflects the development of strategies for encoding and retrieving information. A number of recent experiments in this area will be reviewed in the following section.

Children's Recall of Categorizable Materials

To see if children's recall would be facilitated by the presence of categories in the stimulus list, Vaughan (1968) presented two different types of lists to first, fourth and seventh graders. One list consisted of 16 pictures of objects that were not related to each other (hereafter referred to as an Unrelated list). The other list contained four pictures of objects from each of four conceptual categories. The exemplars of each category were distributed randomly throughout the list. Half of the subjects in each grade were tested with each type of list. The subjects were given a standard free recall test. Following presentation of the pictures, they were asked to recall as many of the stimuli as they could in any order they wished. She found that recall increased with age but in each grade more words were recalled from the categorized list than from the Unrelated list. She also found significant amounts of clustering at each grade level but it was higher for older children.

In an experiment with five- and eight-year-olds, Nelson (1969) tested their recall using three different types of 15-word lists. Two of the lists consisted of three words from each of five different

categories but the sources of the category instances differed. For one list, words were selected from adult category norms while the other list consisted of category instances the subjects themselves had generated during a pre-experimental session. The third list was an Unrelated list. She found that eight-year-olds recalled more than five-year-olds and showed a greater increase in recall across trials. The older children also recalled more words from the two categorized lists than from the Unrelated lists but the younger children exhibited no such superiority for categorized lists. In fact, the five-year-olds tended to recall more words from Unrelated lists. Only on the last two of the six trials did she observe significantly higher levels of clustering for older children than for younger children.

Cole, Frankel and Sharp (1971, Exp. III) contrasted recall of a 20-word list containing five words from each of four different categories with that of a 20-word Unrelated list. Their subjects were in grades 1, 4, 6, and 9. They found superior recall of the categorized list at all grade levels tested. While significant amounts of clustering were exhibited at all grade levels, it tended to be higher for older subjects.

Steinmetz and Battig (1969) used a slightly different procedure. They presented lists in which half the items were related and the remaining were not to children aged 5, 7, 9, 11, and 13 years. For instance, a 24-item list contained four words from each of three conceptual categories plus 12 unrelated words. List length was varied according to the children's ability, as demonstrated on a prior recall

test. They found that recall increased with age and that more related words than unrelated words were recalled at each age. However, they found no significant increase in clustering with age.

One factor that affects adults' recall of categorized lists is the manner in which the category instances are distributed in the list. Cofer, Bruce and Reicher (1966) observed higher recall when the members of each category appeared contiguously during presentation than when they were randomly distributed throughout the list. Hereafter, these lists will be referred to as Blocked lists and Random lists, respectively. They suggested contiguous presentation of the category members may have facilitated the subject's perception of the categories in the list. Similar findings have been reported for children as well.

Moely (1968) constructed stimulus materials using nine different categories, each containing three items. Pictures of three different objects appeared on each stimulus card. For half of the subjects, the three members of each category all appeared on the same card. For the remaining subjects, the three category members appeared on three different cards. (In this condition, the three objects depicted on each card were from different categories.) She tested free recall of six- and ten-year-olds. She found higher clustering and recall for the Blocked presentation condition than for the Random presentation condition at both age levels. In general, clustering was higher for older subjects.

Cole et al. (1971, Exp. II) presented 20-item lists in which the five items from each of four categories were presented together (Blocked

lists) or were distributed throughout the list (Random lists). They tested free recall of children in grades 1, 3, and 8 and, at all ages, both clustering and recall were higher for the Blocked list.

Kobasigawa and Middleton (1972) observed recall of Blocked and Random lists by kindergarteners, third graders and fifth graders. Their lists contained six items from each of four different categories. Blocked presentation resulted in higher clustering at all ages but recall of Blocked lists was superior to that of Random lists only for third and fifth graders. In a subsequent experiment, Kobasigawa and Orr (1973) reduced the number of instances in each category to four and found both clustering and recall by kindergarteners to be higher for Blocked lists.

Only two studies appear to have included all three types of list in the same experiment. Moely and Shapiro (1971) presented 10-item lists to children aged 3, 4, 5, and 6 years. The lists either contained five pairs of related pictures or ten unrelated pictures. In half of the lists, the presentation of the related pairs was blocked, in the other half it was random. Recall of the Blocked lists was consistently highest in all age groups. Unfortunately, they do not report comparisons between recall of Random and Unrelated lists. Clustering increased with age, but only in the blocked condition and clustering was higher for Blocked than for Random lists.

In a similar study, Yoshimura, Moely and Shapiro (1971) tested children aged 4 and 9 1/2 years using 12-word lists. The Blocked and Random lists contained four three-item categories. The Unrelated lists

contained 12 unrelated words. They found higher recall for categorized lists than for Unrelated lists but they did not report data separately for Blocked and Random lists. Clustering was significantly above chance only for the 9 1/2-year-old children.

The youngest age for which organization effects have been demonstrated appears to be two years. Rossi and Rossi (1965) conducted a free recall study with children ranging in age from two to five years. They presented 12-word Random lists containing three words from each of four categories. Both clustering and recall increased as a function of age. More importantly, they found that 26 of the 30 two-year-olds exhibited clustering significantly above chance. Thus, even at this young age, the presence of categories has a demonstrable effect on performance.

The exact relationship between the development of organizational processes and recall is not quite as clear as has been suggested. In addition to several of the studies already reviewed, a number of others have also found parallel increases in both clustering and recall as a function of age. Willner (1967) tested subjects drawn from grades 2, 4, 6, 8, high school and college. He presented 33 pictures from a clinical test of conceptual sorting (the BRL Object Sorting task). He found that both clustering and recall increased as a function of age. Kroes and Libby (1973) constructed a 36-word list using words from two taxonomic categories, two categories derived from the semantic differential (Osgood, Suci & Tannenbaum, 1957) and two sense impression categories ("round" things and "white" things). Their subjects were

fourth, sixth, and eighth graders. They found an overall increase in recall with age. Clustering of taxonomic categories also increased with age but clustering of the other two types of category did not. Wachs and Gruen (1971) presented 40-word categorized lists to subjects ranging in age from seven to seventeen years. Half of the subjects were tested with lists comprised of words from familiar categories; the remaining subjects were tested with words from unfamiliar categories. Clustering increased as a function of age for the familiar-category lists. Presumably, there was also an age-related improvement in recall but they did not report data on recall performance. Perhaps the strongest evidence comes from a study conducted by Shultz, Charness and Berman (1973). They tested children in grades 1 and 4 and found both clustering and recall to increase with age. In addition, they report a significant positive correlation between the two measures.

In contrast, several other investigators have found no clear relationship between clustering and recall. Hasher and Clifton (1974) presented several sets of related words randomly distributed throughout a long list of unrelated words to children in grades 2 and 6. While recall improved with age, there was no significant age difference in clustering performance. Eysenck and Baron (1974) tested five- and eight-year-olds with 16-word categorized lists. Recall was higher for older children. While clustering was significantly above chance for both age groups, they too found no significant effect of age on the level of clustering. Finally, in a study with kindergarteners and

third graders, Horowitz (1969) found an age-related increase in the recall of a categorized list but no increase in clustering. He also found no significant correlation between recall and clustering.

In summary, a number of recent experiments with children have demonstrated that the performance of even quite young children is sensitive to the presence of experimenter-supplied organization in the stimulus list. Yet, a number of age differences are also evident. At least from the studies of Nelson (1969) and Kobasigawa and Middleton (1972) it appears that older children show larger differences in their recall as a result of organizational manipulations than do younger children. While the results are not completely consistent across experiments, it also appears that the amount of organization subjects impose on their recall (clustering) increases with age.

Methodological Considerations

Some of the discrepancies between the studies reviewed in the preceding section may likely be attributable to procedural differences between the studies. Furthermore, there are methodological aspects of some of the studies that pose problems for the interpretation of the results. Several of these aspects will be considered here. The major purpose of the present experiment was to conduct an investigation of the age-related changes in the recall of categorized materials that minimized the methodological problems of previous research.

With two exceptions, none of the earlier experiments included Blocked, Random and Unrelated lists, all in the same study. As outlined

in the preceding section, recall is generally higher for Blocked lists than for Random lists. When these two lists are compared it seems important to also look at performance on Unrelated lists in order to determine if the presence of categories in the Random lists had an effect on recall. Moely and Shapiro (1971) and Yoshimura, Moely and Shapiro (1971) included all three types of lists in their experiments but in neither case was performance clearly reported separately for Blocked and Random lists. All three types of lists were included in the present experiment.

There are also differences in the way categorized materials were generated for use as stimuli in previous experiments. Lange (1973) has demonstrated the importance of distinguishing between the conceptual relationships between words and their associative relationships. He presented lists of 16 items to 5 1/2-, 11-, and 15-year-old children. The lists contained four conceptual categories but the four items within each category were not strongly interassociated. For instance, "pig, squirrel, horse, and giraffe" are all in the "Animal" category but they are not high associates of one another. When recall was tested with such lists, he found a significant level of clustering only for fifteen-year-olds. He suggests that previous demonstrations of "categorical clustering" in very young children, in which the conceptual and associative relationships among the stimuli were confounded, may instead reflect less advanced cognitive behavior based on associative relationships.

In a majority of the previous studies, stimulus words were selected from adult category norms with the provision that the words (often depicted as pictures) be familiar to subjects at all ages tested. This procedure would favor older children since they are more like adults, if it could be demonstrated that the basis for organization changes with age.

Such a change in the predominant basis for organization has been illustrated in several experiments. Hasher and Clifton's (1974) experiment included sets of words that were either phonemically related or semantically related. For second graders, recall was higher for words related phonemically while sixth graders recalled more semantically related words. Rossi and Wittrock (1971) presented 12-word lists to children ranging from two to five years of age. Each list contained six pairs of related words. In two of the pairs the words were phonemically similar (fun, sun), in two other pairs the words were syntactically related (dogs, bark) and in the remaining two pairs the words were taxonomically related (peach, apple). Syntactic clustering in recall was not dominant at any age. Phonemic clustering was dominant for two-year-olds but was infrequently noted thereafter. Taxonomic clustering was dominant from age three until age five where serial order (input-output order correspondence) was most frequent.

Nelson (1969) appears to be the only investigator who used category exemplars actually generated by children. During a preliminary session, she asked her subjects to generate as many instances as possible for

ten different categories. Each subject's recall was later tested using a list comprised of his first three responses to each of five different categories. Although this procedure ensured that each subject was tested with words he considered to be good exemplars of the categories, it was not completely satisfactory because the words used varied across subjects.

In the present experiment, the stimulus words were drawn from recently compiled children's category norms (Posnansky, 1973). The same pool of words was used to test recall of children at all ages in the experiment. Words were selected such that they were considered equally representative of their categories by all of the children.

A related problem is that in most experiments, two different sets of words were used to construct categorized (Blocked or Random) lists and Unrelated lists. This poses special problems for research with children. Specific item selection effects might reasonably be stronger for children than for adults since children's vocabulary is generally smaller. In the present experiment each word was used equally often in each of the three types of list.

Another problem involves the way in which organization is measured. Several clustering indices, for example (O-E)SCR (Bousfield & Bousfield, 1966), are not independent of recall. The maximum value these measures can attain increases as more words are recalled. Thus, the age-related increase in clustering reported by several investigators may be partly attributable to higher recall by older subjects. The notion that recall and organization are intimately related would certainly be

strengthened if a positive correlation between the two measures existed that could not simply be traced to the manner in which the clustering index was computed. A measure of clustering that is independent of the amount recalled was used in the present experiment.

Finally, comparisons among earlier experiments is also hampered because the degree of practice provided the subjects varied from one experiment to the next. For example, Nelson (1969) tested recall after a single exposure of the stimulus list while Vaughan's (1968) subjects were given five presentation trials before recall was ever tested. In the present experiment, performance was assessed after several degrees of learning.

The Locus of Developmental Changes in the Use of Organization

There appears to be reasonably good evidence that older children make more effective use of organization in recall. Given this finding, research has focused on attempts to identify that process(es) whose development is responsible for this age-related improvement. Such an investigation, however, is reasonable only if the following two assumptions hold true. It must be possible to characterize memory development as the development of one or more component processes rather than as an increase in basic memory capacity as a result of maturation. In addition, the use of organization as an aid to recall must involve one or more of those component processes.

Both assumptions appear to be true. A number of investigators (Belmont & Buterfield, 1969; Flavell, 1970; and Hagen, Jongeward, & Kail, 1975) report that almost all the age-related changes in memory performance can be directly tied to the development and use of various mnemonic strategies for encoding and retrieving information. Little developmental change in the basic capacity of memory has been noted.

At the same time, it has been demonstrated in research with adults that both encoding and retrieval processes are involved in the use of organization. The role of encoding processes was illustrated in the part-to-whole transfer experiments conducted by Tulving (1966). The experimental subjects were given half of the List 2 words to learn as List 1. For the control subjects, List 1 consisted of words unrelated to those in List 2. List 2 was identical for all subjects. It would be reasonable to expect higher recall of List 2 by experimental subjects since they had already learned half the words in List 1. In fact, they were superior for only the first few trials. In the later stages of the experiment, List 2 recall was higher for the control subjects. During List 1 learning, the experimental subjects imposed some form of organization on the nominally unrelated words. Since subjects are limited in the number of memory units they can recall (Tulving, 1968), the experimental subjects

were forced to reorganize or enlarge their memory units from List 1 in order to learn List 2 and this resulted in negative transfer.

Tulving and Pearlstone (1966) demonstrated the role of retrieval processes in the use of organization. They presented words belonging to categories accompanied by appropriate category names, telling subjects they would only be asked to recall the category instances. At the time of recall, half the subjects were presented the category names as cues and their recall was higher than that of the subjects who were given no such cues. Since subjects were treated identically prior to the recall test, the superiority of the cued group was attributable to processes operating at the time of retrieval.

A number of experiments have been conducted with children to investigate development changes in the processes involved in the use of organization. Changes in encoding processes were illustrated by Moely, Olson, Halwes and Flavell (1969). Their subjects ranged in age from five to nine years. In the control condition, they presented a randomly ordered array of pictures of objects belonging to four common categories. They asked the child to name each picture as it was presented. The child was then given two minutes to study the stimuli and was told he could rearrange them if he wished. Following this study period, the pictures were removed and the child's recall of the pictures was tested. The Naming condition was identical to the control condition except that the experimenter named the four categories in addition to having the child name each picture. In the Teaching condition, the experimenter

actually taught the child to sort the pictures into the four groups and suggested that, when recalling, it might be helpful if the child first remembered a category and then the items in that category. The child's manipulation of the pictures was recorded during the study period.

For the five- to six-year-olds organizing the pictures occurred with high frequency only in the Teaching condition. It was not evident in the other two conditions. Six- to seven-year-olds used categories to some extent in the Naming condition but again their use was highest in the Teaching condition. By eight to nine years of age, the frequency of categorization in the two experimental conditions did not differ. Subsequent recall was found to be higher for those subjects who manually formed the category groups than for those who did not, regardless of age level. An older group of subjects (ten- to eleven-year-olds) was tested in the control condition and it was found that their spontaneous grouping and later recall was at the same level as that of younger children in those conditions which had facilitated their grouping prior to recall. When children actively grouped stimuli during study, their recall was superior to that of children who did not. Neimark, Slotnick and Ulrich (1971) have replicated this study, extending the age range to include college-aged subjects.

Considerable attention has also been given to developmental changes in retrieval processes. Kobasigawa (1974) found that children of different ages differ in how effectively they use retrieval cues when recalling categorized lists. Twenty-four pictures representing eight

conceptual categories were mounted on a board. A picture of an appropriate retrieval cue was mounted next to each stimulus. For instance, each of the three animal pictures was accompanied by a picture of a zoo. The experimenter pointed out this stimulus-cue relationship during presentation of the pictures. The 6-, 8-, and 11-year-old subjects were divided into three different recall conditions. The control group was given typical free-recall instructions. The children in the cue condition were given a deck of cards identical to the cues presented initially and were told that they could use the cards to help them remember. Subjects in the directive cue condition were shown this same deck of cards, one card at a time and were required to name as many category exemplars as possible for each cue before the next one was presented.

Recall was highest in the directive cue condition and there were no age differences. Evidently, subjects of all ages stored and retrieved the information equally well in that condition. In contrast, there was a large increase in recall with age in the cue condition. While recall of the 11-year-olds in the cue and directive cue conditions did not differ, recall in the cue condition was lower for younger subjects. In the cue condition, subjects as old as eight years were not using the cues as efficiently as they could whereas the 11-year-old subjects were able to recall exhaustively all the members of a category whether required to do so (directive cue condition) or not (cue condition). The clustering data for the cue condition yielded another interesting

finding. High clustering was observed for 11-year-olds, indicating they recalled all, or most of, the items from one category before moving on to the next. In contrast, younger children yielded low clustering scores. The experimenter reports that these subjects often went through the deck of cue cards several times, each time attempting to recall only one exemplar of a category before proceeding to the next.

Tumolo, Mason and Kobasigawa (1974) demonstrated that the strategy of exhaustively recalling all the exemplars of a category develops with age. First and third graders were presented a list of 24 items. There were three pictures from each of eight conceptual categories. Each of the three pictures in a category was accompanied by a picture of an appropriate cue for that category. When recall was tested, the child was given a deck of cue cards and was told that they might be helpful in recalling the pictures. In the informed condition, three blue squares, indicating the number of exemplars in the category, appeared with the picture of the category cue on the card. Only the category cue appeared on each card for subjects in the uninformed condition.

For third graders, there was no difference in recall between the two cuing conditions. First graders' recall was significantly higher in the informed condition. Apparently in either situation, third graders were equally adept at exhaustively recalling most of the exemplars of a category. In contrast, without the additional information about category size, first graders did not exhaust their memory for the elements of one category before proceeding to the next.

In another study of retrieval processes, Halperin (1974) tested 6-, 9-, and 12-year-old children on a 36-item list consisting of nine different categories. Presentation of the categories was blocked and the experimenter said the category name prior to presenting the exemplars. In one condition, subjects were given standard free-recall instructions. Subjects in the cue condition were required to recall all items within a category after the experimenter named the category.

In this latter condition, there were no differences among age groups in their recall of different categories (recalling at least one exemplar of a category) but there were strong age differences in the non-cued condition. Apparently the categories were available to children of all ages but only the older children were able to rely upon their own retrieval strategies to gain access to these categories when the category cues were not provided.

In summary, developmental changes in both encoding and retrieval processes are evident in children's utilization of organization in recall. When opportunities to manipulate the stimuli are minimal or presentation is fairly rapid, then most of the developmental changes can probably be traced to changes in retrieval processes.

The Present Experiment

The primary purpose of the present experiment was to conduct an investigation of age-related changes in the recall of categorized materials that minimized the methodological problems in previous studies. Specifically, all three types of list, Blocked, Random, and Unrelated,

were used. Stimulus words were selected from children's category norms, thus ensuring that each word was considered representative of its category by children of all ages in the experiment. All three types of list were constructed from the same pool of words. Measures of organization that are independent of the amount recalled were computed. Finally, a multi-trial, free-recall task was used so that performance could be analyzed after several degrees of learning.

For Unrelated lists a measure of clustering can not be computed because the lists do not contain experimenter-defined categories. When presented such lists, subjects are free to organize the words into groups of their own choosing and use these subjective units as a basis for recall. Tulving (1962) defined subjective organization as the tendency for the same words to be grouped together in recall on repeated trials. Several studies with children (Laurence, 1966; Rosner, 1971; and Shapiro & Moely, 1971) have all found relatively low levels of subjective organization compared to that demonstrated by adults and have not found large increases with age until the children are quite old. Subjective organization in the recall of Unrelated lists was measured in this experiment to see if comparable levels would be obtained.

A second purpose of the experiment was to provide additional evidence as to the locus of developmental changes in children's use of organization. The Selective Reminding task (Bushke, 1973, 1974a) was used for this purpose. In the Selective Reminding task, a child is presented only the words he was unable to recall on the preceding trial.

Several different measures, based on multi-store models of memory (e.g., Atkinson & Shiffrin, 1968 and Waugh & Norman, 1965), can be derived from a child's performance. For example, a child can demonstrate retrieval of information from long-term memory by recalling a word on a trial when it was not presented. Or, the degree of list learning can be determined from the number of words that can be consistently retrieved from long-term memory. Analysis of these component measures of memory was undertaken as a possible way of determining those processes that change with age in the recall of categorized materials and those that do not. The correlations between the components of memory derived from the Selective Reminding task and (1) the measures of organization and (2) performance on a simple recognition task were computed to provide independent validation of the component measures.

CHAPTER II

METHOD

Subjects

The subjects were 36 second graders, 36 fourth graders, and 36 sixth graders. Equal numbers of boys and girls were tested within each grade. The children were white, from middle-class homes and attended a private, parochial school in Ann Arbor, Michigan. Mean ages of second, fourth, and sixth graders were 7.9 years (s.d. = .31), 10.0 years (s.d. = .36), and 12.0 years (s.d. = .35), respectively. An additional four second graders, one fourth grader, and two sixth graders were tested but were not included in the sample. Their data were discarded either because they did not understand the instructions (two subjects), because they failed to complete all 12 recall trials (two subjects), or because their testing session had to be discontinued due to external interruptions (three subjects).

Stimulus Materials

Word Lists

Each list presented for recall and recognition contained 16 words. The words in each list were selected from a master pool of 64 common nouns consisting of four exemplars from each of 16 categories (from (Posnansky, 1973). (The categories are presented in Appendix A.) Categories were chosen so as to minimize similarities among them. For example, the category "Fruits" was selected but the category "Vegatables" was not because both fall under the larger category of "things to eat."

In addition, an attempt was made to avoid choosing words from the same category that were associated strongly. For example, "dog" was selected for use but "cat" was not because of the strong association between these two words. Words were chosen such that, with one exception, all were among the ten most frequent responses given by second graders in the Posnansky norms. In general, these words were also among the 10 most frequent responses for both fourth and sixth graders. Six words (listed in Appendix A) failed to meet this criterion but in no case was their rank higher than 14. Thus, the master pool of 64 words consisted of four words from each of 16 conceptual categories that, to a very good approximation, were considered to be equally good exemplars of their respective categories by children in grades 2, 4, and 6. Three different types of lists were constructed from this pool of 64 words such that, for all three types of list, each word was used equally often.

Blocked lists. Four different Blocked lists (B_1, B_2, B_3, and B_4), each containing 16 words, were constructed. B_1 consisted of four categories randomly selected from the set of 16. B_2, (B_3 and B_4) consisted of four categories randomly selected from the remaining 12, (8 and 4) categories. The four exemplars of one category within a list were all presented before a word from a different category was presented. The order of appearance of the four categories, and the four words within each category, was determined randomly for each list but was constant for each child tested with that particular list. The four Blocked lists are presented in Appendix A.

Random lists. Four different Random lists (R_1, R_2, R_3, and R_4), each containing 16 words, were also constructed. The four different sets of 16 words used in lists R_1, R_2, R_3, and R_4 were the same sets of words used in lists B_1, B_2, B_3, and B_4, respectively. However, the serial position of each word in the Random lists was randomly determined with the following two restrictions: (1) two words from each category appeared in the first half of the list and the other two words from each category appeared in the last half of the list; and (2) no two words from the same category were presented successively. Once the order of words was determined for a particular Random list, it remained constant for all subjects tested with that list. The four Random lists are presented in Appendix A.

Unrelated lists. Finally, four different Unrelated lists (U_1, U_2, U_3, and U_4), each containing 16 words, were constructed by randomly assigning the four different exemplars of each category to a different list. Thus, each list contained one word from each of the 16 categories. The order of words was determined randomly for each list, but was constant for all subjects tested with that list. The four Unrelated lists are presented in Appendix A.

Recognition test lists. Each child was given a simple yes-no recognition test. First he was presented one of the 16-word lists described above that was the same type of list used to test his recall but contained different words. For example, a subject who would be

presented list B_1 for recall, was presented list B_2 for the recognition task. The recognition task involved presentation of a second list containing 32 words: Sixteen words were from the list presented initially; the other 16 words were distractor words the child had not heard previously (presented in Appendix A). All words were ordered randomly in the test list.

The same 16 distractor words were used in testing the recognition performance of all subjects. They were not members of any of the 16 categories represented in the master pool of 64 words nor were they related to one another. Seven distractor words were selected from seven categories that were not used in constructing the master word pool, using the same rank criterion used in selecting words for the master pool. Nine additional common nouns were selected such that their frequency of occurrence in children's vocabulary (Rinsland, 1945) was comparable to that of the 64 words in the master pool.

Four different random assignments (A_1, A_2, A_3, and A_4) of the 16 distractor words to the 32 serial positions in the recognition test list were constructed with the restriction that a distractor word appeared in each of the 32 serial positions in two of the four orders. The remaining 16 serial positions in each recognition test list were filled randomly with the 16 words that had been presented initially with the restriction that, in the Blocked and Random list conditions, no two words from the same category were presented successively.

The A_1 order of distractors in the recognition test list was used when testing recognition of lists B_1, R_1, and U_1, the A_2 order was used

when testing lists B_2, R_2, and U_2, etc. Thus, across subjects, the only difference between the recognition tests used in the three list-type conditions was the structure of the lists initially presented to the subjects.

Sorting Task Stimuli

Color photographs (2 1/2 x 3 in.) of drawings corresponding to the 64 words were mounted separately on pieces of stiff cardboard. The word was printed in lower-case letters below the object because it was difficult to select a distinctive picture for each of the 64 words (for example, "father" and "uncle"). A 24 x 18 in. piece of poster board, divided into four rectangular quadrants by one horizontal and one vertical strip of dark tape, was also used.

Design

Three conditions were determined by the structure of the lists presented for recall (Blocked, Random, and Unrelated). These three conditions were completely crossed with the three school grade levels (grades 2, 4, and 6) resulting in nine experimental groups. Nested within each list-type condition were the four different counterbalancing lists for that condition. Twelve children, 6 boys and 6 girls, were assigned to each of the nine experimental groups. Three of the children within each group were tested with each of the 4 different counterbalancing lists. Finally, children in each grade were drawn from two different classrooms and an attempt was made to equate the number of children from the two rooms in each of the experimental groups.

Procedure

Each child was tested individually by the author in an isolated room in one session lasting about 30 to 35 min. (Typically, the session was slightly shorter for the older children.) The experiment was conducted during a four-week period in April and May, 1975.

The experimenter told the child that he could help the experimenter find out how people remember things by playing some memory games with him. The child was informed that no one, other than the experimenter, would know how well he performed on the games, but that it was important he do his best so that the experimenter could get a good idea of how people remember.

Recognition Task

The child was first given the recognition task. He was told that he would hear a list of 16 words and that he should listen carefully to each word and try to remember it. He was informed that when the experimenter finished reading the words, he would be told what to do next. After the experimenter had read the 16 words at the rate of one word every 2 sec, the child was informed that he would be read a second list and that he should pay careful attention to each word. If he thought the word was one the experimenter had just read in the first list, he was instructed to say "yes", but if he thought it was a new word, one that the experimenter had not read before, then he was to say "no". The experimenter then read the recognition test list and recorded the subject's response to each word.

Recall Task

The Selective Reminding task was used to test recall performance. On the first trial of this task, the subject is presented the entire list (in this experiment, 16 words). Following presentation of the list, the subject is given unlimited time for free recall of the to-be-remembered words. When the subject has finished recalling as many words as he can, the experimenter presents only the words the subject failed to recall on that trial and then the subject is given a second chance to recall the entire list. This procedure is repeated for a specified number of trials (in this experiment, 12 trials). On each trial the experimenter presents only the words the subject failed to recall on the immediately preceding trial but the subject is always required to try to recall the entire list.

Instructions were designed to maximize the information about the task available to the child. The child was told that people can really remember more words than they think they can and that, by playing this memory game, he would see that that was true for him. The child was told that he would hear a list of 16 words and that when the experimenter had finished reading the words, the child should try to say as many of the words as possible in any order. He was also told that he would be given 12 chances (trials) to say the words because 16 words was probably too many for him to remember at one time. He was informed that the experimenter would only tell him the words he missed the time before but that he (the child) should always try to say all 16 of the words. The child was encouraged to take his time; he was told that even though

he felt he could recall no additional words, if he waited a few seconds, he probably would. Finally, the child was informed that he would probably be able to say more words each time until he had remembered the entire list.

The experiment began when the experimenter was sure the child understood the nature of the task. Sixteen words were read by the experimenter at the rate of one word every 2 sec. When the entire list had been read, the child tried to recall as many words as possible. The experimenter recorded the words recalled by the child and the order of recall. On all trials the experimenter encouraged the child to recall as many words as possible. If the child recalled a word he had already said or recalled a word that was not on the list, the experimenter informed him of that fact immediately. Whenever the child requested, the experimenter told him how many words he had yet to recall. When the child failed to say any more words for a period of 30 sec, the experimenter asked him to take a few more seconds to see if he could remember more. The trial was terminated if the child did not recall any additional words for 30 sec after that prompt. If new words were recalled, the experimenter repeated the procedure and waited an additional 30 sec before ending the trial. An additional, standard prompt was given to each subject at the end of trial 2 to make certain the subject understood the instructions. The child was reminded to try to recall any words he had said before (trial 1) in addition to the words he had already recalled on trial 2.

The same general procedure was repeated for 12 trials with the experimenter making every attempt to get the child to recall as much as possible before initiating the next trial.

Sorting Task

Following the recall task, all children tested with the Blocked and Random lists were given a randomly ordered deck of 16 pictures, corresponding to the words they had tried to recall. The child was asked to put the pictures into four groups of things "that go together"; one group in each of the four rectangular quadrants of the sorting board. The experimenter demonstrated what he meant by groups of things "that go together" before presenting the 16 pictures to the second graders. He presented a set of 6 pictures unrelated to those in the recall lists (3 garden tools and 3 musical instruments) and asked the child to put them into 2 groups of 3 things that go together. If the child failed to understand the task the experimenter demonstrated by forming the two groups. After this simple demonstration for second graders, and with no such demonstration for fourth and sixth graders, the child was given unlimited time to form the four appropriate groups.

Description of Dependent Measures

Components of Memory

In addition to total recall, several measures of the components of memory can be derived using the Selective Reminding task (Bushke, 1973). Because this task is relatively new, these measures will be described

here. The recall protocol for a 9 year old boy is presented in Figure 1. He was given 12 trials to recall the 16 words in a Random list. The words are listed on the left. The 12 columns on the right correspond to the 12 recall trials. The stippled cells show which words were presented on each trial. All cells in column 1 are stippled because all the words were presented on that trial. A number in a cell indicates the word in that row was recalled on the trial corresponding to that column. The value of the number represents that word's position in the output protocol for that trial. A number in a stippled cell means the subject recalled a word that was presented on that trial. A number in an unstippled cell means the subject was able to recall a word that was not presented on that trial.

Long-term storage (LTS). A word is assumed to be retrieved from long-term memory when a subject is able to recall it on a trial when it was not presented. It is further assumed that the word was stored in long-term memory on the immediately preceding trial and that it remains there for the duration of the experiment. This assumption appears justified by the results of several recent studies (Bushke, 1974a,b) where a slightly different procedure was used. In this task, words were presented only until their first recall and then were never presented again, even if the subject failed to recall them on subsequent trials. Using this procedure, the number of words originally stored in long-term memory (LTS), that were subsequently lost from memory could be determined. This value averaged less than one word from a 20 word list and was approximately the same for both children and adults.

LIST R1		TRIALS 1	2	3	4	5	6	7	8	9	10	11	12
1.	snow		2		3	4	11	6	3	14	4	4	7
2.	pants			6	11	12	5	8	7	8	14	6	15
3..	screwdriver	2		4	7	10	8	4	10	5	6	14	10
4.	shirt	1	5	9	5	3	4	1	4	7	5	5	14
5.	butterfly	3	4	10		7	7		1	9	10	11	8
6.	hammer	6	6	8	10	9	10	13	12	4	7	13	9
7.	sunshine					13	13	11		1	13	9	5
8.	spider		8		6	11	6	12	5	10	9	12	13
9.	rain		1		4	5	12		2	15	3	3	4
10.	saw				1		1	10	9	12		1	3
11.	dress			3			2		13		1	8	12
12.	wrench	4	7	7	8	8	9	5	11	6	8	15	11
13.	cloudy			5	9	6		2	14	13	2	2	6
14.	mosquito	7	3		2	2	14	7	6	2	12	10	2
15.	shoe			2			3	9	8	11	15	7	16
16.	grasshopper	5		1		1		3	15	3	11		1
	Total Recall	7	8	10	11	13	14	13	15	15	15	15	16
	LTR	5	5	7	10	12	13	13	14	15	15	15	16
	STR	2	3	3	1	1	1	0	1	0	0	0	0
	LTS	5	5	8	11	12	14	15	15	15	16	16	16
	Consistent LTR	3	3	5	8	8	9	10	12	13	14	15	15
	Random LTR	2	2	2	2	4	4	3	2	2	1	0	1

Fig. 1. Recall protocol of a nine-year-old boy using the Selective Reminding task.

In Figure 1, the trial on which a word is first stored is indicated by heavy underlining beginning on that trial and continuing to the end of the experiment. Operationally, LTS is a cumulative measure of the number of words that have been stored on or before a given trial. Theoretically, LTS represents a minimal estimate of the number of items that have been stored in long-term memory and are consequently available for recall.

Long-term retrieval (LTR). Any word recalled that has been stored in long-term memory is assumed to be retrieved from long-term memory. Thus, LTR equals the total number of LTS words actually recalled on each trial. The total LTR measure can be broken down into two components.

Consistent LTR. Consistent LTR is a cumulative measure of the number of words that the subject is able to recall without further failure and is taken as a measure of list learning. Bushke (1973) suggests such words have been encoded within an organized structure in long-term memory or that the retrieval of such words has been integrated with the retrieval of other words in an organized retrieval search. For each word, the trial on which it becomes a Consistent LTR word is indicated by an arrow on the recall protocol in Figure 1.

Random LTR. Random LTR refers to those words that the subject has learned to retrieve from long-term memory but cannot yet be consistently retrieved as part of the list. Random LTR on each trial equals total LTR minus Consistent LTR for that trial.

Retrieval from short-term memory (STR). On each trial, those words that were recalled, but not retrieved from long-term memory (LTR),

are considered to be retrieved from short-term memory (STR). STR equals Total Recall minus LTR on each trial.

Measures of Organization

The clustering and the subjective organization (SO) measures used in this study differed slightly from those used in previous research and the method of their calculation is described here.

Clustering ratio. Clustering is observed in the recall of categorizable lists and refers to the subject's tendency to recall together words from the same category. Measures of clustering usually are based on the number of pairs of words from the same category recalled in succession (runs). The clustering measure used here was based on a measure introduced by Bousfield (Bousfield & Bousfield, 1966; Bousfield & Puff, 1964), in which clustering is expressed as the deviation of the observed number of runs from the number of runs that would be expected by chance. The expected value, E(r), is calculated separately for each subject, on each trial, and is defined by the following formula:

$$E(r) = \frac{\sum_{i=1}^{k} m_i}{N} - 1$$

where m is the number of words recalled in category k and N is the total number of words recalled. The deviation measure, O(r) - E(r), is not independent of the number of words recalled. Its maximum value increases as the subject recalls more words. Therefore, this value was converted to a proportion of the maximum number of runs possible using a procedure similar to that suggested by Fagan (1968). The maximum number of runs,

Max(r), can be represented by

$$\text{Max}(r) = \sum_{i=1}^{b} (m_i - 1)$$

where $\underline{m}$ is the number of words recalled in category $\underline{b}$ and category $\underline{b}$ was represented by at least one word in the output protocol.

This proportion is also not completely satisfactory because the proportion can never achieve a value of 1.00 (for this experiment the highest value possible was .75) and is still slightly dependent upon the number of words recalled. To ensure that the value of 1.00 could be achieved, the expected number of runs was subtracted from the maximum number as well as the observed number. The clustering ratio used in this experiment is represented by

$$\text{clustering ratio} = \frac{O(r) - E(r)}{\text{Max}(r) - E(r)}$$

On the few occasions when O(r) - E(r) was less than zero, the ratio was given the value of zero. This ratio represents the ratio of the observed number of runs, not attributable to chance, to the maximum number of runs not attributable to chance.

SO ratio. The subjective organization index that was used is also based on a deviation measure introduced by Bousfield (Bousfield, Puff, & Cowan, 1964). It measures the tendency of subjects to recall words together in the same groups on repeated trials. An intertrial repetition (ITR) is defined as recall of two words together, in the same order, on two successive trials. The measure is calculated between trials n and

n+1 and here, the value obtained has been attributed to the second of the two trials. The expected (ITR) is given by the formula

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

Where h is the number of words recalled on trial n, k is the number of words recalled on trial $n+1$, and W is the total number of words presented for learning (i.e., list length). The deviation score has been converted to a proportion in the present experiment for reasons analogous to those given for the clustering measure. It takes the form

$$SO\ ratio = \frac{O(ITR) - E(ITR)}{Max(ITR) - E(ITR)}$$

where Max(ITR) = c-1, and c is the number of words that appear in the recall protocols of both trials n and $n+1$.

CHAPTER III

RESULTS

Three aspects of the data are of primary interest and will be discussed here. First, the mean total recall will be analyzed to determine the effects of age and list structure on recall performance. Next, the measures of organization, clustering ratio and SO ratio, and the components of memory derived from the Selective Reminding task will be analyzed, in an attempt to interpret the developmental differences in total recall. Finally, the correlations between the components of memory derived from the Selective Reminding task and (1) the measures of organization and (2) recognition performance will be analyzed to provide some independent validation of the component measures.

Total Recall

Mean total recall as a function of trials and list type is plotted separately for each grade in Figure 2, page 38. It can be seen that recall of the Blocked lists by fourth graders and recall of both the Blocked and Random lists by sixth graders was perfect on late trials in the experiment. This ceiling effect restricts the variance for the recall measures on those trials. Spuriously high F ratios would be obtained if data from the late trials were included in an analysis of variance. Therefore, the first analysis was restricted to data from trials 1 to 6 where none of the nine groups had yet reached the level of perfect recall. The factors included in the analysis were list type

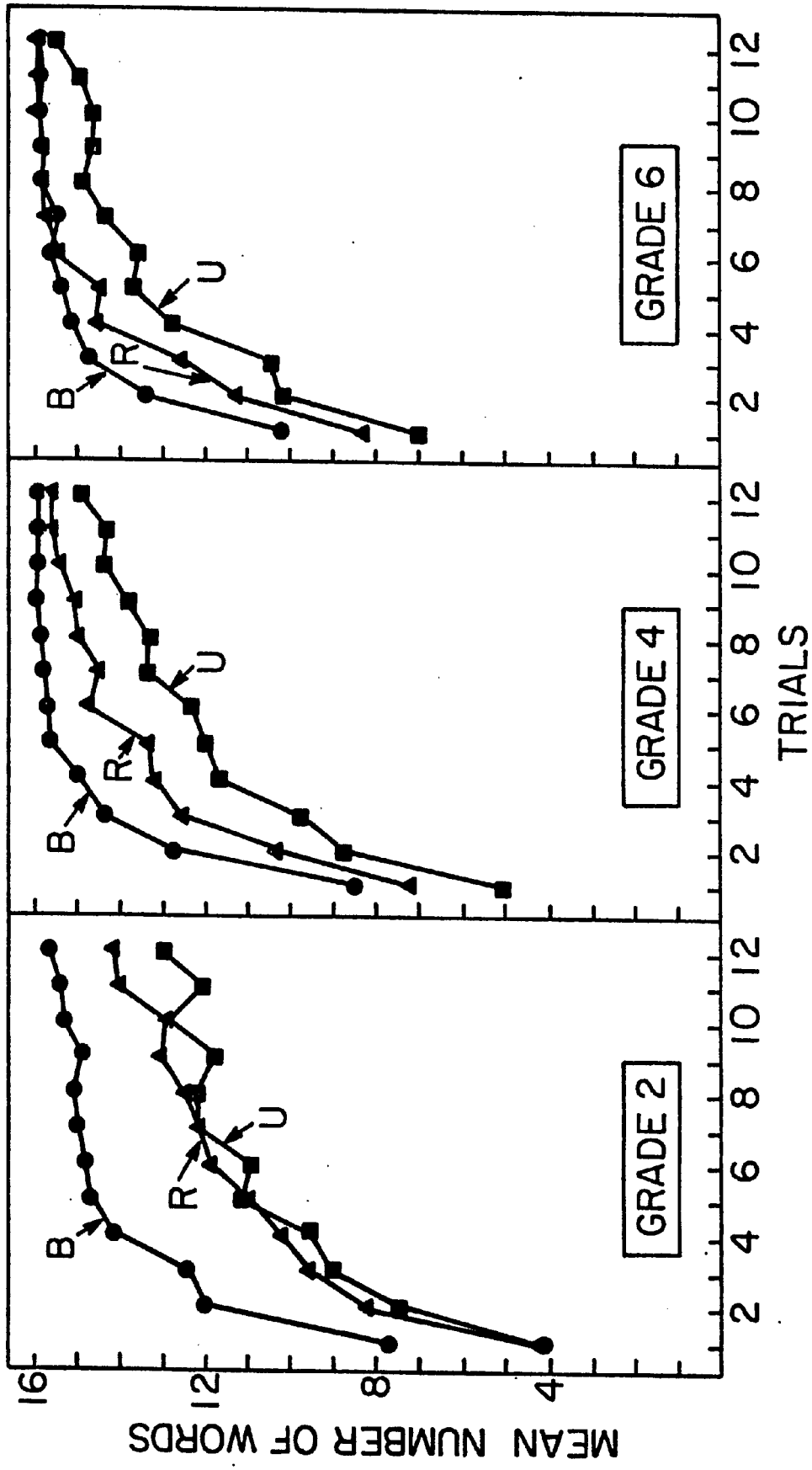


Fig. 2. Mean number of words recalled correctly as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

(3 levels), grade (3 levels), counterbalancing list nested within list type condition (4 levels), subjects nested within each combination of grade and counterbalancing list (3 subjects) and trials (6 repeated measures). The proportion of words correctly recalled by a child on each of the 6 trials was transformed for this analysis using the arcsin transformation to equate the variance across groups and trials (Winer, 1971).

The main effects of list type and grade level were both significant, $F(2,72) = 65.39$, $p < .001$ and $F(2,72) = 29.89$, $p < .001$, respectively. Scheffé confidence intervals were computed to test comparisons among group means (Scheffé, 1959). The difference between two means was considered significant when the confidence interval for that difference failed to include zero. The .05 level of significance was adopted for all such comparisons.

It was found that more words were recalled from Blocked lists than from Random lists and, in turn, more words were recalled from Random lists than from Unrelated lists. In addition, sixth graders recalled more than fourth graders, who recalled more than second graders.

The main effect of trials was also significant, $F(5,360) = 309.70$, $p < .001$. This reflects the obvious improvement in recall across trials for all groups.

The interaction between list type and trials was significant, $F(10,360) = 2.93$, $p < .005$. This interaction may be an artifact attributable to a ceiling effect. Recall of the Blocked lists begins to level off after trial 3 as performance approaches a maximum, while recall

of the Random and Unrelated lists does not. None of the other interactions was significant.

While the interaction between list type and grade level did not reach a level of significance, $F(4,72) = 1.79$, several interesting comparisons do appear in Figure 2 and they were tested using Scheffé confidence intervals. Caution should be exercised in evaluating the importance of these results, given the non-significant interaction. Nevertheless, there is an interesting pattern present that would probably achieve significance with a more powerful experiment.

It was found that both fourth and sixth graders recalled more words from Random lists than did second graders. In fact, there was essentially no difference between second graders' recall of Random and Unrelated lists. Recall of Random lists appeared to be superior to that of Unrelated lists for children in grades 4 and 6 but in both cases the difference was not quite significant.

It was also found that in grade 4, recall of Random lists was significantly lower than recall of Blocked lists, but this same comparison was not significant in grade 6. Thus, fourth graders showed a greater discrepancy in their recall of Blocked and Random lists than did sixth graders. This difference is especially apparent if attention is directed towards performance on trials 7 to 12 although these trials were not included in the analysis for the reasons outlined above.

Finally, there was no difference between the recall of Blocked lists by children in grades 4 and 6. Second graders' recall of Blocked lists did appear lower than the level for grades 4 and 6 but this

difference was not significant. Again, with a larger sample, a significant difference would probably be obtained.

Because recall by second graders in all three list conditions failed to reach the level of perfect performance on any trial, a separate analysis was conducted on the second graders' recall that included all 12 trials. Again, the proportion of words correctly recalled on each trial, for each subject, was transformed using the arcsin transformation. The factors included in the analysis of variance were: list type (3 levels), counterbalancing lists nested within the list type conditions (4 levels), subjects nested within counterbalancing lists (3), and trials (12 repeated measures).

The main effects of list type and trials were both significant, $F(2,24) = 22.67$, $p < .001$ and $F(11,264) = 77.21$, $p < .001$, respectively. The interaction of list type with trials was not significant ($F < 1$). Thus, the superior recall of Random lists compared to Unrelated lists for the last few trials did not achieve a level of statistical significance.

In summary, the two analyses of total recall yielded several results of interest. First, more words were recalled from Blocked lists than from Random lists and more words were recalled from Random lists than from Unrelated lists. Second, sixth graders tended to recall more words than fourth graders who, in turn, recalled more than second graders. However, there was no difference between grades 4 and 6 in their recall of Blocked lists. At the same time, fourth graders' recall of Random lists was significantly lower than their recall of Blocked lists but

the same comparison was not significant for sixth graders. Finally, there was no difference between second graders' recall of Random and Unrelated lists while recall of Random lists appeared higher than that of Unrelated lists for fourth and sixth graders. Again, caution is urged in evaluating these latter findings in light of the non-significant list type x grade level interaction. Still, the pattern observed seems quite reasonable and was supported by subsequent analyses.

Measures of Organization

Measures of the extent to which a child organized his recall were computed for each trial. Clustering ratios were computed for recall of the two types of categorized lists (Blocked and Random). Subjective organization (SO) ratios were computed for recall of the Unrelated lists.

Clustering ratios. The clustering ratios for Blocked and Random lists are plotted as a function of trials, separately for each of the three grades, in Figure 3, page 43. The ratio on each trial, for each subject, was transformed using the arcsin transformation. The factors included in the analysis of these data were list type (2 levels), grade (3 levels), counterbalancing list nested within list type condition (4 levels), subjects nested within grade crossed with counterbalancing list (3), and trials (12 repeated measures).

The main effect of list type was significant, $F(1,48) = 57.40$, $p < .001$ with Blocked lists resulting in more clustering than Random lists. Grade level was significant, $F(2,48) = 19.75$, $p < .001$, with sixth graders exhibiting more clustering than fourth graders and fourth

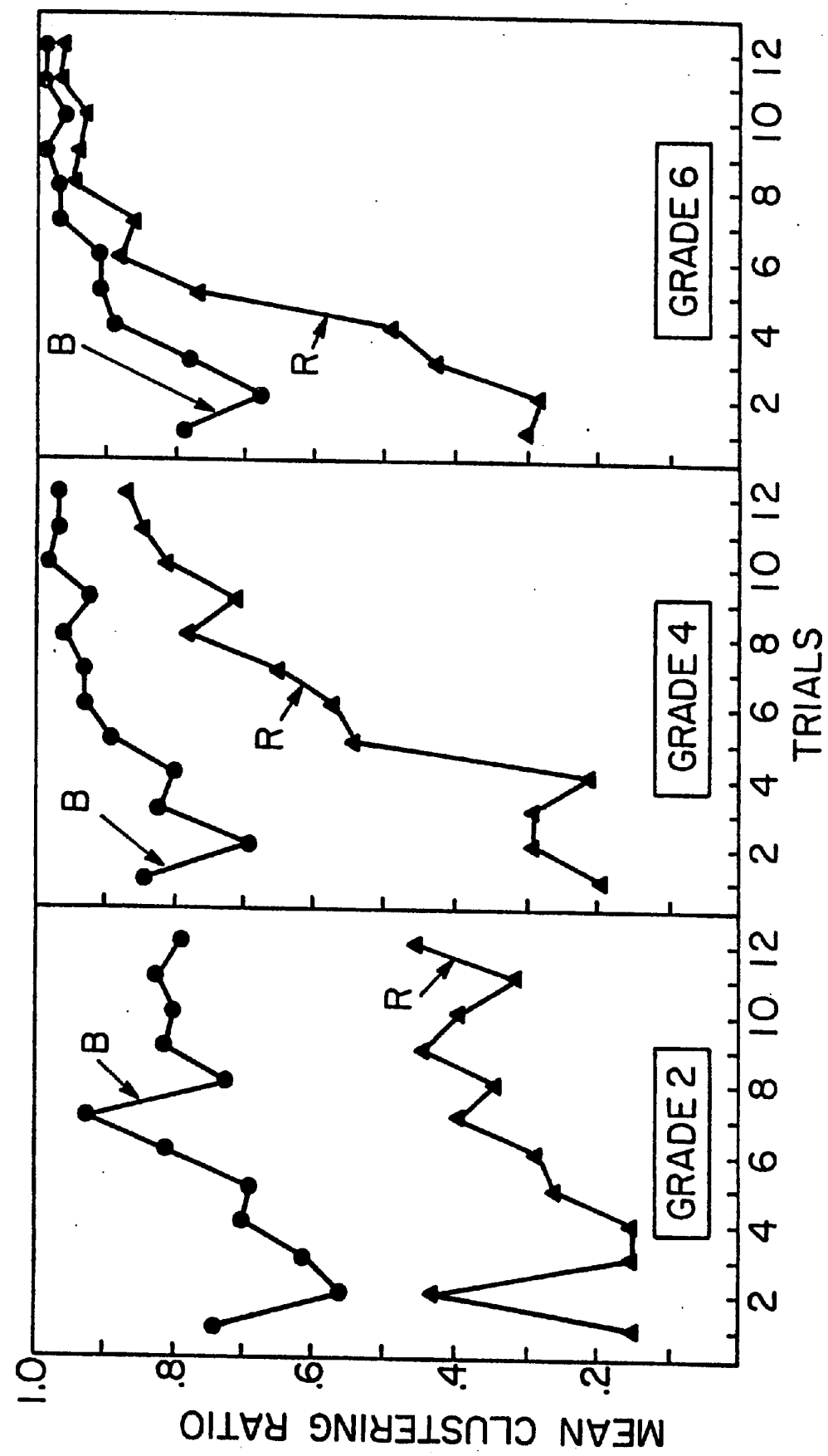


Fig. 3. Mean clustering ratio as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

graders exhibiting more than second graders. The main effect of trials was also significant, $F(11,528) = 26.15$, $p < .001$, reflecting the general increase in clustering across trials.

The list type x grade level interaction was only marginally significant, $F(2,48) = 2.46$, $p < .10$. Overall, Scheffé confidence intervals indicated that the difference between clustering for Blocked and Random lists was significant for second and fourth graders but not for sixth graders. The list type x trials interaction was significant, $F(11,528) = 3.69$, $p < .001$, attributable to the greater difference between clustering for Blocked and Random lists on early trials than on late trials. Finally, the grade x trials interaction was significant, $F(22,528) = 2.74$, $p < .005$, reflecting the fact that, in general, both fourth and sixth graders showed a greater increase in clustering across trials than did second graders.

The three-way interaction of list type x grade level x trials was not significant ($F < 1$). At first, this result is surprising in light of what appears to be a strong interaction between these three factors in Figure 3. While the two curves are essentially parallel for second graders, in the other two grades they appear to converge, especially for sixth graders. It must be remembered, however, that the data plotted in Figure 3 are proportions whereas the analysis of variance was conducted on the arcsin transformations of those proportions. The transformed curves are essentially parallel for all three grades and, thus, the three-way interaction would not be expected to reach a significant level.

One interesting finding is that, while clustering in the recall of Blocked lists by second graders improves across trials, it never reaches a maximum level, within the limits of this experiment, as it does for fourth and sixth graders. This is similar to the finding reported by Kobasigawa (1974) that first grade children failed to recall exhaustively all the members of a single category in response to a category cue before moving on to another category. Only later did they return to the original category and try to recall additional words from it. Such behavior would result in a lower clustering score and would be less efficient than the strategy of exhaustively recalling all members of one category before moving on to another, a strategy demonstrated by older subjects in Kobasigawa's study.

Given that the clustering ratio is an index of the amount of organization a subject imposes on his recall and given the further assumption that recall is dependent on organization as argued by Mandler (1967) and Tulving (1968), then the findings of interest in the recall data of this experiment can be interpreted in terms of the clustering performance.

In Figure 3, clustering in the recall of Blocked lists is nearly identical for fourth and sixth graders. This equality is true not just for the late trials where performance is restricted by a ceiling effect, but for early trials as well. The ceiling effect for the late trials does prove troublesome when evaluating the equivalence of clustering performance on those trials. Perhaps if a longer list or different stimulus materials had been used, then clustering performance would not

have reached a maximum and the sixth graders might then have demonstrated a superiority over fourth graders. With this reservation it is still safe to say that both fourth and sixth graders achieve a maximum level of clustering on about the same trial and that prior to that their clustering performance is also equivalent. Consistent with this result is the finding of no difference in recall of Blocked lists for fourth and sixth graders (Fig. 2, p. 38). It appears that in both grades the same high degree of organization was imposed on recall with correspondingly high levels of recall achieved also.

Another result was that fourth graders clustered less in their recall of Random lists than in their recall of Blocked lists but the same comparison was not significant for sixth graders. Fourth graders also recalled fewer words from Random lists than from Blocked lists while sixth graders did not show a similar significant difference (Fig. 2, p. 38). Why should the fourth graders exhibit this relatively lower organization on Random lists when they have demonstrated the ability to cluster at the same level as sixth graders when recalling Blocked lists? One possible interpretation is suggested by Tumolo, et al. (1974). While fourth graders may have detected the presence of categories in the Random lists as well as sixth graders, they may have had more difficulty in determining the number of members in each category when category exemplars were scattered throughout the list. Fourth graders' uncertainty as to the category size may have made it more difficult for them to recall exhaustively all the members of a

category, reducing the levels of recall and the organization they imposed on recall.

Finally, second graders, unlike fourth and sixth graders, did not demonstrate the dramatic increase in clustering for Random lists. Their recall of Random lists was also well below that of the fourth and sixth graders.

The preceding interpretations of recall in terms of organization are dependent on the existence of a strong relationship between clustering and recall. Correlations between the clustering ratio and total recall are presented for Blocked and Random lists in Table 1. Correlations were computed for the pooled means of trials 1 to 6 and the pooled means of trials 7 to 12. Because recall performance on late trials was essentially perfect for fourth and sixth graders on the Blocked lists and for sixth graders on the Random lists, the variance was very small for those measures. Thus, the correlations based on trials 7 to 12 were largely uninterpretable and only those for trials 1 to 6 are reported.

TABLE 1

CORRELATION BETWEEN THE CLUSTERING RATIO AND TOTAL RECALL

	Grade 2	Grade 4	Grade 6
Blocked Lists	.63*	.71**	.70*
Random Lists	.26	.81**	.17

*$p < .05$

**$p < .01$

The correlations between organization and total recall of Blocked lists were significant for all three grades. For the Random lists, the pattern of correlations between clustering and recall appears reasonable for second and fourth graders. Both clustering and recall were comparatively low for second graders and it is not unreasonable that they bore little relation to each other. Evidently, second graders imposed less organization on their recall and, when they did, it did not seem to affect recall. At the same time, fourth graders exhibited a much higher level of both clustering and recall and the two were significantly related.

The correlation obtained for the sixth graders between mean recall and mean clustering over trials 1 to 6 proves perplexing, however. There was a high level of both clustering and recall for those subjects and yet no relationship between the two was detected. It must be remembered that each of these correlations was based on a sample of only 12 subjects. With such a limited sample, the data from just one or two deviant subjects would have a large effect on the correlation.

Analysis of the recall protocols for these sixth graders revealed a similar pattern on several of the trials for several of the children. They appeared to recall two categories together. For example, words from categories A and B were recalled in the order A-A-B-A-B-B-A-B. It is as if the child started to recall words from category A, then thought of a word from category B. After recalling that word he remembered he had not finished recalling category A, and so on. On almost all such trials, the children recalled more than the mean number of words

for that trial but their clustering ratio was below its mean because it was not sensitive to the type of idiosyncratic organization these children imposed on their recall.

The preceding argument certainly does not provide a full explanation for the lack of correlation found for sixth graders on the Random list. However, it does suggest that the obtained value may be abnormally low and should be interpreted with some caution.

In summary, the correlations between clustering and recall of Blocked lists support the interpretation of recall performance in terms of organization. Evidently, the extent to which a subject can organize his recall, has at least some determining effect on its level. Fourth and sixth graders exhibited both equivalent levels of clustering and equivalent levels of recall. Second graders clustered less than older children and they also recalled less.

In general, similar support comes from the correlations for Random lists, to the extent that the sixth graders' correlation can be considered of questionable validity. In both clustering and recall, fourth graders showed a greater discrepancy between Blocked and Random lists than did sixth graders. Also, second graders exhibited much less clustering in their recall of Random lists and the organization present had little effect on their recall.

SO ratios. Mean SO ratios derived from recall of Unrelated lists are plotted in Figure 4, page 50, as a function of trials and grades. The ratios were computed for each pair of successive trials. Here the value obtained has been attributed to the latter of the two trials and,

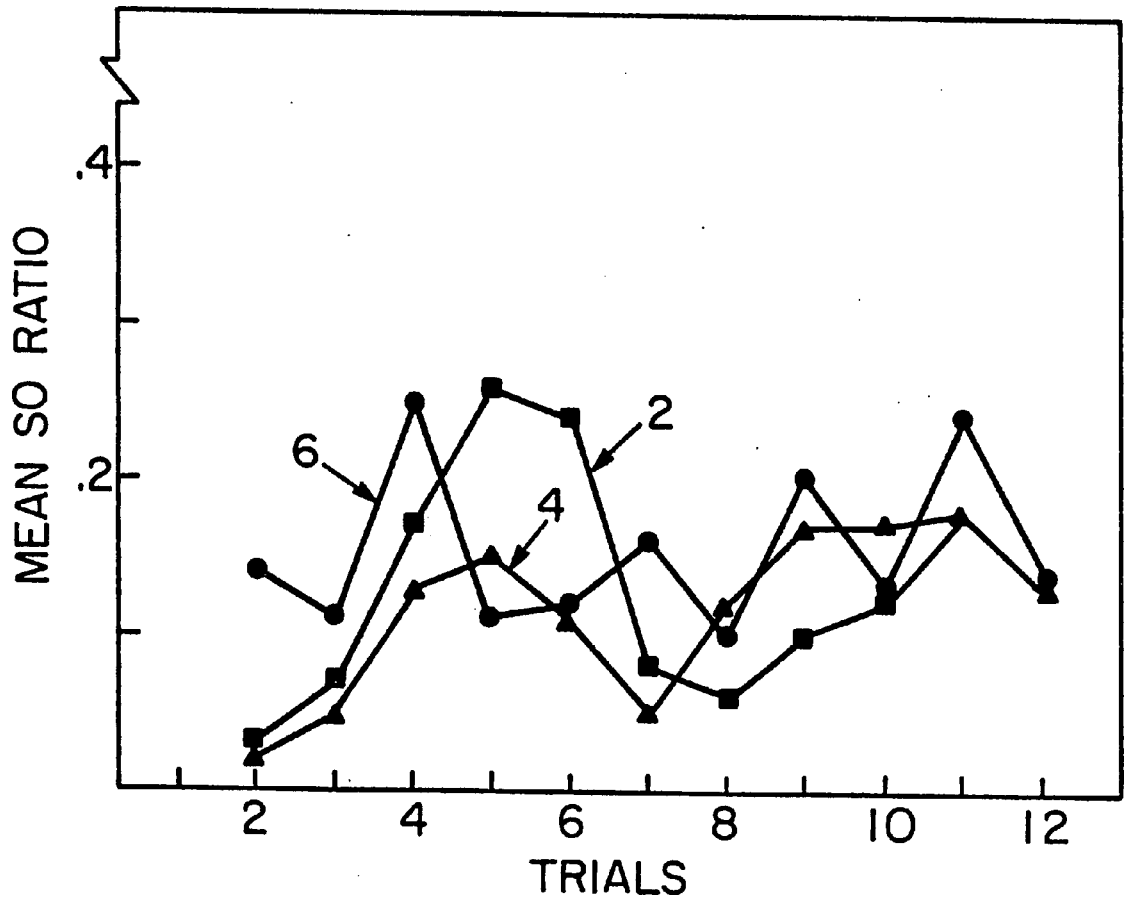


Fig. 4. Mean SO ratio as a function of trials and grade level; 6 - sixth grade, 4 - fourth grade, 2 - second grade.

therefore, there is no value for trial 1. The organization imposed on Unrelated lists appears to have been relatively low and did not differ between grades. Analysis of variance confirmed that the only significant effect was the main effect of trials, $F(10,240) = 2.31$, $p < .05$. There was a slight increase in the overall SO ratio across trials.

Several comments should be made about these findings. No comparisons between the clustering ratios and the SO ratios can be made since the two are computed in different ways. Also, other investigators (Laurence, 1966; and Rosner, 1971) have found similar low levels of subjective organization in children's recall. It is possible that the measure of subjective organization used here, as well as in other studies, is not very sensitive to the organization children impose on their recall of lists of unrelated words. Here, an intertrial repetition was defined as the adjacent recall of two words, for example a and b, in the same order on two successive trials. If on one trial the order of recall was a-b and on the next it was b-a then, although the two words appear to be grouped together, that organization would not be detected. Furthermore, the measure is not sensitive to organization spanning three or more trials such as a-b-c, c-b-a, and a-b-c. Because of these limitations, the SO ratio calculated here seems of limited value and will not be considered more extensively.

Components of Memory

A direct relationship between organization and recall was described in the preceding section, with older children generally demonstrating

both higher organization and higher recall. It is possible that clustering primarily reflects processes operating at the time of retrieval and thus older children possess better strategies for utilizing organization in the retrieval of information. Alternatively, the clustering measures may reflect processes operating during storage. That is, the information is initially grouped into categories, the subject then stores it that way and, when tested, simply recalls the information in whatever form it was originally encoded in. Thus, it would seem that older children are better able to organize information when first acquiring that information. For evidence as to the locus of the age-related improvement in the use of organization in recall, attention will now be turned to several of the components of memory derived from the Selective Reminding task.

The estimate of the number of words that have been stored in long-term memory on or before a given trial and are available for recall (LTS) is plotted in Figure 5, page 53, as a function of trials and list type, separately for each of the three grades. This measure (LTS) is not independent across trials because it is a cumulative measure. This violates the basic assumption of independence in the analysis of variance model and therefore, no analysis was computed on these data. (For similar reasons, no analysis of variance was conducted for any of the other component measures either.) Instead, LTS, and the other component measures are treated simply as descriptive measures. Caution must be exercised in their interpretation since it is not known whether the differences observed for these measures are statistically significant.

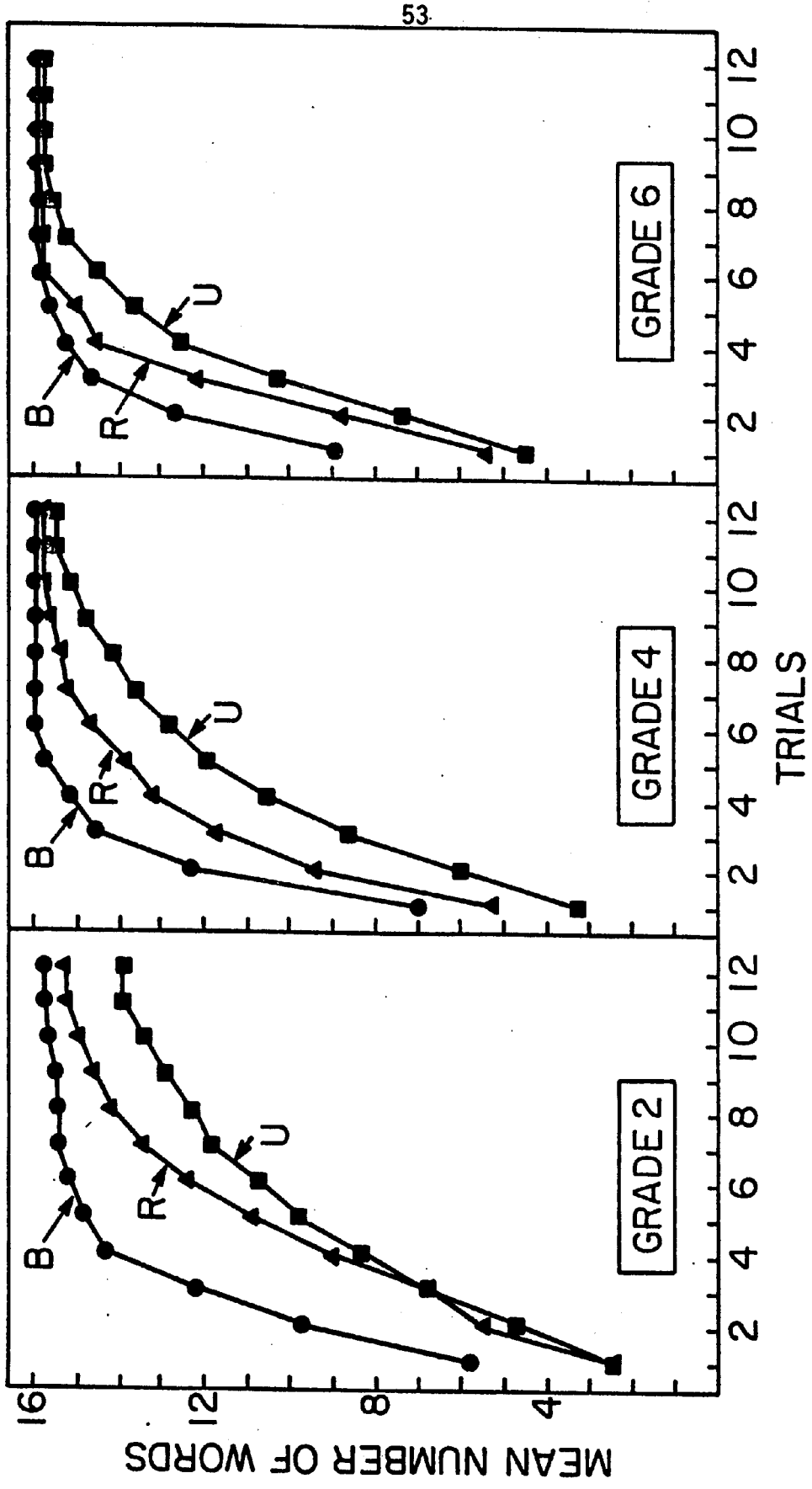


Fig. 5. Mean number of words stored in long-term memory (LTS) as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

Nevertheless, possible explanations for the recall findings are suggested from these data and, therefore, they will be presented.

With the exception of second graders on early trials, more information was stored for Blocked lists than for Random lists and more was stored for Random lists than for Unrelated lists. In grade 2, the superiority of Random lists over Unrelated lists was not apparent until after three or four trials. It is possible that it took second graders several trials before they ever detected that categories were present in the list and therefore no difference between Random and Unrelated lists would be expected.

The measure of long-term retrieval, LTR, and Consistent LTR, the measure of list learning, are not independent of LTS; consequently, they reflect patterns similar to those in Figure 5 and they will not be presented here. (Figures analogous to Fig. 5 for LTR and Consistent LTR, as well as STR and Random LTR, are presented in Appendix B.) It is instructive, however, to look at both LTR and Consistent LTR as proportions of LTS. That is, what proportion of the words available in long-term memory is the subject able to retrieve (and consistently retrieve) on each trial?

The mean ratio of LTR to LTS is plotted as a function of trials and list types in Figure 6 separately for each grade. (By definition, LTR equals LTS on trial 1 so the proportion must equal 1.00 for that trial.) Two interesting results emerge. First, second graders retrieved similar proportions of the words available in long-term memory when either Random or Unrelated lists were presented. Thus, although

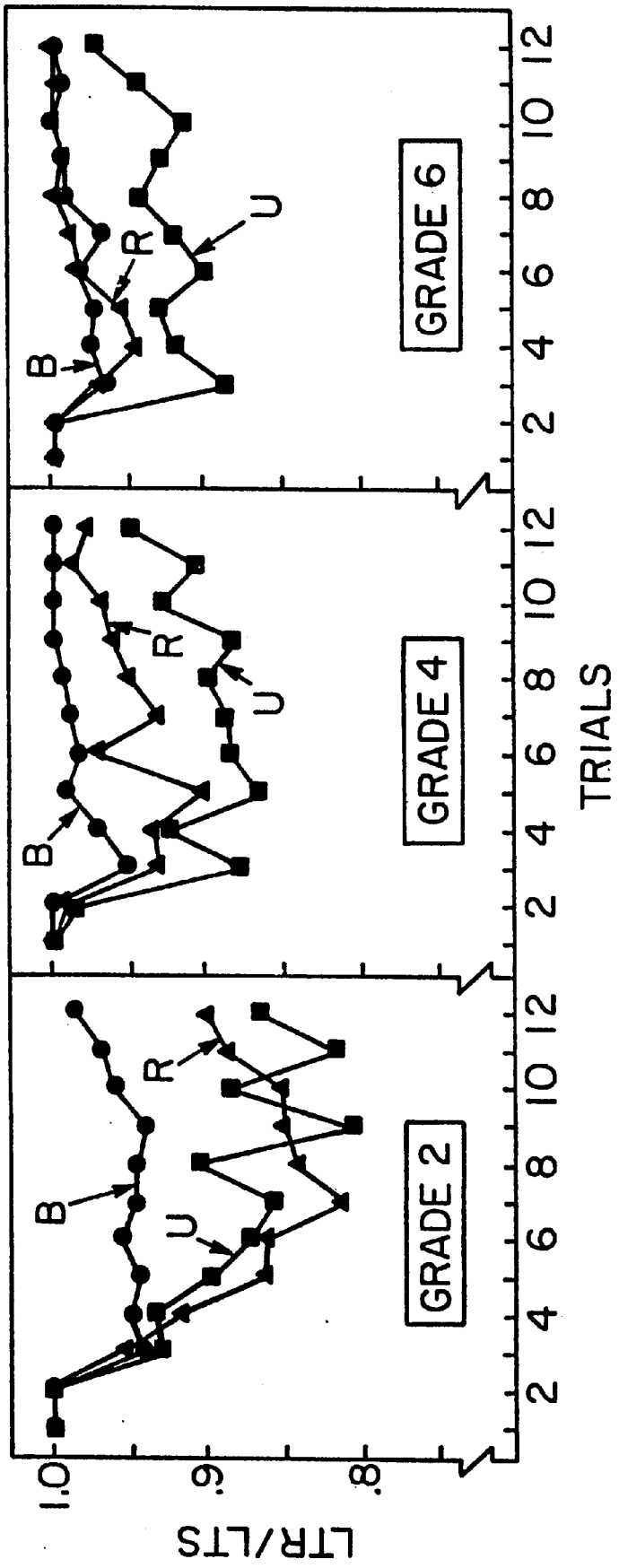


Fig. 6. Mean LTR/LTS ratio as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

second graders appeared to detect the presence of categories in the Random list at least by trial 5, as evidenced by the higher level of storage for Random lists than for Unrelated lists on late trials in Figure 5, they were unable to use them effectively to aid retrieval. Also, fourth and sixth graders were similar to each other in the proportion of Blocked list words they retrieved from long-term memory, but fourth graders showed a difference between Blocked and Random lists while sixth graders did not. Thus the fourth graders did not seem as efficient as sixth graders in the retrieval of Random list words from long-term memory.

The same pattern appears even more clearly for the proportion of words in long-term memory that are consistently retrieved. In Figure 7, page 57, the mean ratio of Consistent LTR to LTS is plotted in a manner analogous to Figure 6. Here the data represent the proportion of words available that the child has learned to retrieve consistently as part of the list. It is especially interesting that, for second graders, the proportion of Random list words retrieved was actually below that of the Unrelated lists until trial 8.

A comment should be made about the data presented in Figures 6 and 7. It can be seen in Figure 5 that, except for Random and Unrelated lists on early trials in second grade, the LTS measure differs for the three types of lists in each grade. Thus, in analyzing the absence of a difference in Figure 6 for the LTR/LTS ratio between Random and Unrelated lists for second graders, the following argument might be made:

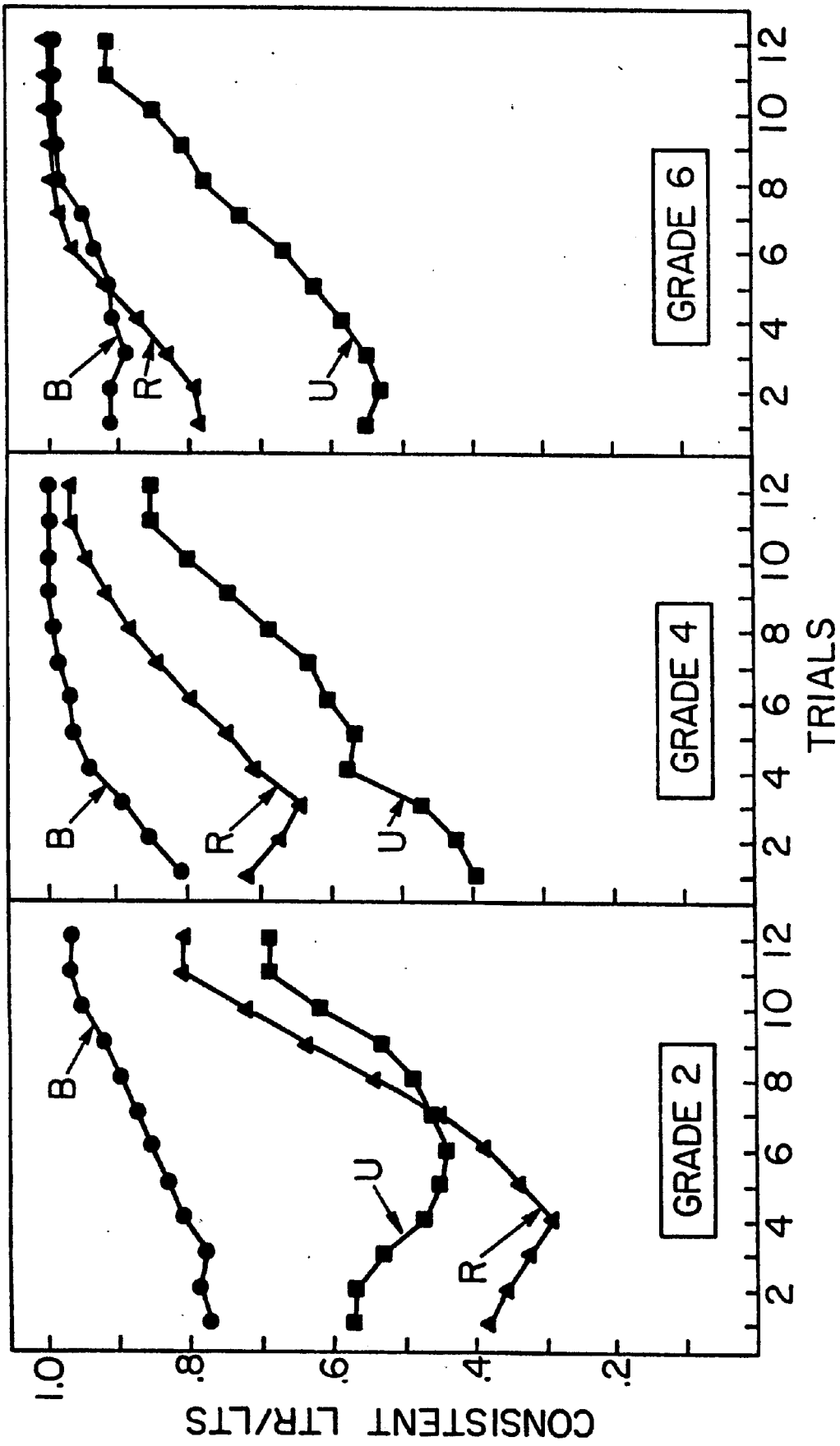


Fig. 7. Mean Consistent LTR/LTS ratio as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

Since LTS on late trials was higher for Random lists than for Unrelated lists, then in order for the LTR/LTS ratio to be equal for the two lists, LTR must have been higher for the Random lists as well. Thus, it would appear that the second graders were able to retrieve more words from long-term memory on each trial for Random lists than for Unrelated lists. Evidently they seemed to detect the presence of the categories and used them to modify their retrieval attempts to some extent. When viewed in this way, in isolation from the other two grades, the data for second graders in Figures 6 and 7 are not that impressive. It must be remembered, however, that for both fourth and sixth graders, LTS was also higher for Random lists than for Unrelated lists. Yet in recalling Random lists, these older subjects did not merely increase their retrieval from long-term memory (LTR) to a level that maintained the same LTR/LTS ratio as for the Unrelated lists. Instead, retrieval was increased beyond that point, such that the LTR/LTS ratio increased. It is this ability to actually increase the proportion of words retrieved from long-term memory, even though the absolute number of words there was larger, that second graders did not exhibit in their recall of Random lists and it is in this sense that their retrieval activities appear less well developed than those of the older subjects.

In summary, there is some evidence that for second graders, it took several trials before they exhibited a difference in the amount of information from Random and Unrelated lists they had stored in memory. More striking, however, is the fact that lower recall of Random lists in

grades 4 and 6 was most directly related to problems they had in the retrieval of words from those lists.

Sorting Task

Following the last trial of the recall task, each child tested with a Blocked or Random list was asked to sort the pictures corresponding to the stimulus words into the four appropriate categories. Every child in all three grades was able to construct the four groups without error. These results confirm that the categories used were fairly common and salient for the children in all three grades.

Memory Component Correlations

Clustering. Correlations between each of the six component measures of memory derived from the Selective Reminding task and the clustering ratio are presented in Table 2 for Blocked and Random lists. Correlations were computed for the pooled means of trials 1 to 6 and trials 7 to 12 for each of the three grades and two list types. As noted earlier, the correlations for late trials had little meaning because recall performance was so high for several of the groups on those trials. Therefore, only the data from trials 1 to 6 are reported.

Significant correlations were found most consistently for the data from Blocked lists. Since the clustering ratio is an index of the amount of organization a subject imposes on his recall, it is not unreasonable that the correlations tended to be positive for those four measures that increased across trials (Total Recall, LTR, LTS, and Consistent LTR) and negative for those that decreased across trials

TABLE 2

CORRELATIONS BETWEEN THE CLUSTERING RATIO AND THE COMPONENTS OF MEMORY

Components of Memory	Grade 2	Grade 4	Grade 6
		Blocked Lists	
Total Recall	.63*	.71**	.70*
LTR	.63*	.72**	.71*
STR	-.59*	-.57	-.68*
LTS	.64*	.71**	.64*
Consistent LTR	.54	.74**	.75**
Random LTR	-.28	-.61*	-.69*
		Random Lists	
Total Recall	.26	.81**	.17
LTR	.38	.85**	.27
STR	-.43	-.59*	-.33
LTS	.27	.83**	.32
Consistent LTR	-.14	.87**	.13
Random LTR	.59*	-.55	.07

*$p < .05$

**$p < .01$

(STR and Random LTR). A similar pattern exists in the recall of Random lists only for fourth graders. (The absence of significant correlations between the clustering ratio and total recall for second and sixth graders was discussed in an earlier section, and those arguments apply to the other component measures as well.)

The pattern of correlations obtained does little besides separating the memory components into two groups, those that increased across trials and those that decreased. It is possible that the processes underlying each of the four different measures, Total Recall, LTR, LTS and Consistent LTR, are all strongly dependent on organization. Alternatively, the four measures may reflect a similar underlying process and not tap different aspects of memory at all. These two alternatives can not be decided on the basis of the data presented here.

Recognition. The mean number of distractor words recognized falsely was less than one for all nine groups and showed no discernible pattern as a function of grade or list type. Accordingly, it was assumed that the false recognition rate did not vary. Thus, the mean number of old words recognized correctly, out of a possible set of 16, is a meaningful measure of recognition performance and is presented in Table 3. The only significant effect was the main effect of Grade, $F(2,72) = 3.47$, $p < .05$, reflecting the slightly higher overall performance of sixth graders in comparison to the two younger samples.

TABLE 3

MEAN NUMBER OF WORDS CORRECTLY RECOGNIZED

	Grade 2	Grade 4	Grade 6
Blocked Lists	13.50	12.67	13.50
Random Lists	11.75	12.92	13.00
Unrelated Lists	12.17	11.25	13.50

Performance on the recognition task presumably reflects amount of information stored in memory, largely independent of retrieval processes (Kintsch, 1970). Thus, it was expected that recognition performance should be related most strongly to LTS, the estimate of what has been stored in memory in the Selective Reminding task. Correlations between the number of words correctly recognized and the components of memory pooled over trials 1 to 6 are presented in Table 4. Again, data from trials 7 to 12 have been omitted for reasons outlined previously.

The correlations are significant primarily only for the recall of Blocked lists by fourth graders. For those children, most of the correlations were significant, not just the one for LTS. This pattern is similar to that obtained for the correlations with clustering and again it appears that the component measures may not really be tapping different underlying processes.

TABLE 4

CORRELATIONS BETWEEN RECOGNITION PERFORMANCE AND THE COMPONENTS OF MEMORY

Components of Memory	Grade 2	Grade 4	Grade 6
		Blocked Lists	
Total Recall	.11	.67*	.61*
LTR	.11	.61*	.57
STR	-.10	-.30	-.41
LTS	.11	.59*	.61*
Consistent LTR	.17	.73**	.57
Random LTR	-.24	-.77**	-.50
		Random Lists	
Total Recall	-.04	-.18	-.01
LTR	-.08	-.19	-.02
STR	.11	.12	.02
LTS	-.08	-.15	-.16
Consistent LTR	-.45	-.26	.28
Random LTR	.31	.26	-.45
		Unrelated Lists	
Total Recall	.48	.54	.28
LTR	.46	.53	.21
STR	-.33	-.25	.04
LTS	.46	.42	.29
Consistent LTR	.50	.58*	.03
Random LTR	.11	-.46	.20

*$p < .05$

**$p < .01$

CHAPTER IV

DISCUSSION

The intent of this study was to investigate developmental changes in the effects of experimenter-supplied organization on children's recall. Several interesting findings were noted. In the preceding chapter, caution was urged in the interpretation of some of the results because the observed differences were not always statistically significant. Nevertheless, the differences were theoretically interesting and the fact that similar patterns were obtained on several different measures lends credence to the results.

There was no difference between fourth and sixth graders in their ability to recall Blocked lists. Second graders' recall of Blocked lists appeared to be below that of the older two groups but this difference was not significant. It was also found that for both second and fourth graders, their recall of Random lists was significantly lower than their recall of Blocked lists but this same comparison was not significant for sixth graders. In fact, second graders' recall of Random lists was so low that there was essentially no difference between its level and their level of recall of Unrelated lists. For the two older groups, recall of Random lists appeared superior to that of Unrelated lists but in both cases the difference just failed to reach a level of statistical significance.

Significant positive correlations between clustering and the recall of Blocked lists were observed for all three grades. For Random lists, only fourth graders exhibited a significant correlation. Considering both types of categorized list, there was a similarity between the pattern of age differences observed in recall and the pattern observed in clustering performance. Thus, there was some support for the notion that the higher recall of older children, at least in part, may be attributed to the higher level of organization they impose on their recall.

Hagen, Jongeward, and Kail (1975) have noted that many of the age-related improvements observed in memory performance can be traced to the development of strategies for encoding and retrieving information. The components of memory derived from the Selective Reminding task were analyzed with the expectation that they would be useful in determining which process showed the greatest change with age.

Two interesting results emerged when retrieval from long-term memory (LTR) was plotted as a proportion of the words available for retrieval (LTS). In grade 4, this ratio was consistently lower for Random lists than for Blocked lists but in grade 6, there was essentially no difference between the two types of list. Thus, fourth graders, but not sixth graders, exhibited a retrieval deficit in their recall of Random lists relative to their recall of Blocked lists. Because the proportion of words retrieved from Blocked lists was the same for the two grades, fourth graders presumably were capable of retrieval equivalent to that

of sixth graders. Their retrieval deficit when recalling Random lists, then, seems more closely tied to problems that occurred when they initially stored those lists. It is possible that when the category members were distributed throughout the list, fourth graders were somewhat less likely to detect the presence of all the categories. Thus, they could not use them as effectively when they were encoding the words. The possibility that some words had not been incorporated within an organized structure would make their retrieval more difficult and result in the observed retrieval deficit.

It is also possible that with random presentation, fourth graders had more trouble determining the exact number of instances in each category. This uncertainty about category size would make it more difficult for them to retrieve all the members of each category. The effect of category size information on exhaustive retrieval was clearly demonstrated by Tumolo et al. (1974).

Analysis of the proportion of words retrieved from long-term memory indicated that second graders also exhibited deficiencies in retrieval. Part of their deficit can probably be traced to the same storage problems experienced by fourth graders. However, it appears that their performance was also hampered by a further problem. It was noted that their recall of Blocked lists appeared to be lower than that of older children. Even if they detected the presence of the categories and used them to organize storage, they may not have used that information when trying to retrieve the words. Ritter, Kaprove, Fitch and Flavell (1973)

have shown that the active use of specific retrieval cues develops with age. Kobasigawa (1974) and Halperin (1974) reported that young children failed to use category cues spontaneously but could do so when such behavior was required of them. It is possible, then, that part of the second graders' problem in this experiment was their failure to employ effective retrieval strategies.

The following plan reported by a fourth-grade girl, tested with a Blocked list, illustrates the elaborate retrieval activities many older subjects engaged in. She first recalled the four animals, always saying "lion" last. She used the fact that a lion is yellow to remember the color category. "Yellow" and "blue" she found especially easy to remember because they are the colors of The University of Michigan. She used spatial relationships to group the parts of a building. ("The 'floor' is connected to the 'wall' and a 'door' and 'window' are both on a wall.") Finally, she remembered the names of family members by relating them all to the word "father." For example, "an 'uncle' is the brother of a 'father'." Not only did this child organize each category and develop a direct link between at least two of the categories, she also exhibited a good deal of flexibility in choosing the basis for organizing each group.

While the preceding explanations of the recall findings are certainly reasonable, the data from this experiment really do not permit the conclusive determination of the separate contributions of encoding and retrieval processes. Several theorists (Wood, 1972; Thomson &

Tulving, 1970; and Tulving & Thomson, 1973) argue that these two processes are intimately related in the use of organization and that it may be extremely difficult to separate them experimentally.

Previous studies have shown that when required to do so (1) young children can group stimuli during presentation and this facilitates their subsequent recall (Moely et al., 1969) and (2) young children can use category cues effectively as retrieval aids (Kobasigawa, 1974). Why, then, do these children not exhibit such behaviors spontaneously? One possibility is that they do not realize the usefulness of such organization.

Two recent studies support this hypothesis. Tenney (1975) asked kindergarten, third and sixth grade children to generate lists of words under several different instructions. She found that kindergarteners generated essentially identical lists whether they were required to give words that would be easy to remember with a key word or were required simply to give free associates to a key word. On the other hand, identical lists were generated by the two older groups when they were asked to give words that would be easy to remember and when they were asked to give words that were in the same category as a key word. Moynahan (1973) presented pairs of cards to 7-, 9-, and 10-year-olds. One card of each pair contained several pictures from conceptually related classes, while items on the other card were not related. The child's task was to select the set of items that would be easier to remember. Both older groups selected the card with categorized items more frequently than did seven-year-olds. This difference was maintained when

the analysis was restricted to only those subjects that detected the categories.

Moynahan suggests that the "awareness of the facilitative effect of categorization on recall may depend, in part, upon more elementary kinds of knowledge about memory (i.e., that remembering is a different activity from naming and identifying and that there are limits to one's recall abilities)" (Moynahan, 1973, p. 245). The results of the present experiment and previous studies of organization in children's recall may be additional examples of a more general phenomenon suggested by Flavell (1970). He states that there are two important aspects of memory development. First the child must realize that his memory is limited and that a general, planful approach is necessary if his attempts at memorizing are to be successful. In addition, the child must acquire specific mnemonic skills (i.e., strategies) and learn to apply them in response to the demands of a specific task.

APPENDIX A

WORD LISTS

A master pool of 64 common nouns was constructed using category norms recently compiled by Posnansky (1973). She asked children in grades 2 through 6 to generate instances of 25 different categories. Separate category norms were reported for each grade with the instances ranked according to their frequency of appearance. Sixteen of the categories were selected for use in this experiment and they are listed below. Four exemplars from each of the 16 categories were then chosen such that, in general, all words were among the ten most frequent responses given by second, fourth, and sixth graders. The single exception for second graders was "plate", ranked 11. For fourth graders, "ear" and "mosquito" were ranked 11 and 13, respectively and for sixth graders, "hand," "plate," "butterfly," and "dandelion" were ranked 11, 12, 11, and 14, respectively.

Categories

Animals
Carpenter's Tools
Clothing
Colors
Denominations of Money
Flowers
Fruits
Furniture
Insects
Kitchen Utensils
Parts of a Building
Parts of the Body
Relatives
Sports
Vehicles
Weather Phenomena

Blocked Lists

mosquito	horse	hand	banana
butterfly	lion	ear	grapes
spider	dog	leg	pear
grasshopper	elephant	nose	apple
snow	door	hockey	dollar
rain	wall	swimming	penny
sunshine	window	baseball	nickel
cloudy	floor	tennis	dime
saw	blue	spoon	lamp
screwdriver	yellow	bowl	chair
hammer	brown	fork	table
wrench	green	plate	bed
shoe	uncle	tulip	truck
dress	grandmother	daisy	car
pants	father	rose	bus
shirt	sister	dandelion	train

Random Lists

snow	dog	spoon	dollar
pants	blue	daisy	table
screwdriver	sister	baseball	dime
shirt	door	hand	bus
butterfly	horse	swimming	grapes
hammer	window	leg	train
sunshine	green	plate	banana
spider	father	rose	bed
rain	elephant	ear	apple
saw	floor	bowl	penny
dress	uncle	tulip	car
wrench	wall	hockey	chair
cloudy	yellow	dandelion	nickel
mosquito	grandmother	nose	lamp
shoe	lion	fork	truck
grasshopper	brown	tennis	pear

Unrelated Lists

horse	penny	sunshine	dime
dollar	lion	nickel	sister
hockey	grandmother	spider	dandelion
door	car	window	nose
uncle	butterfly	rose	plate
lamp	ear	father	tennis
saw	bowl	pants	elephant
banana	screwdriver	table	green
truck	grapes	brown	train
blue	daisy	bus	cloudy
snow	rain	fork	bed
mosquito	yellow	leg	apple
shoe	floor	baseball	shirt
hand	dress	dog	wrench
tulip	chair	pear	grasshopper
spoon	swimming	hammer	wall

Recognition Task Distractor Words

bridge
yardstick
year
farm
soap
skeleton
telephone
violin
cotton
hotel
maple
parrot
flag
tomato
milk
doll

APPENDIX B

COMPONENTS OF MEMORY

Measures of (1) the mean number of words retrieved from long-term memory (LTR), (2) the mean number of words consistently retrieved from long-term memory (Consistent LTR), (3) the mean number of words randomly retrieved from long-term memory (Random LTR), and (4) the mean number of words retrieved from short-term memory (STR) are presented in Figures A, B, C, and D, respectively. In all cases, performance is plotted as a function of trials and list type, separately for each grade.

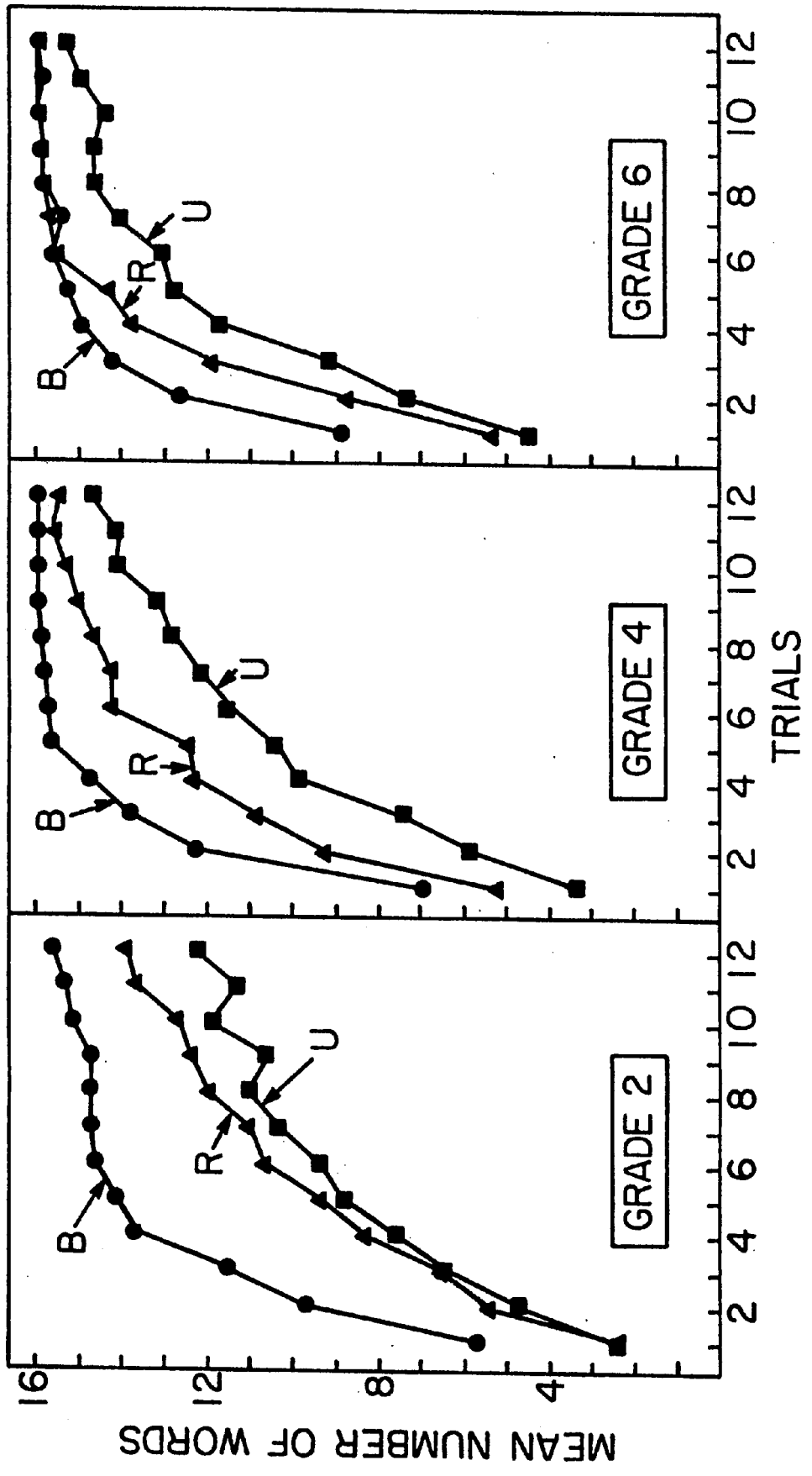


Fig. A. Mean number of words retrieved from long-term memory (LTR) as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

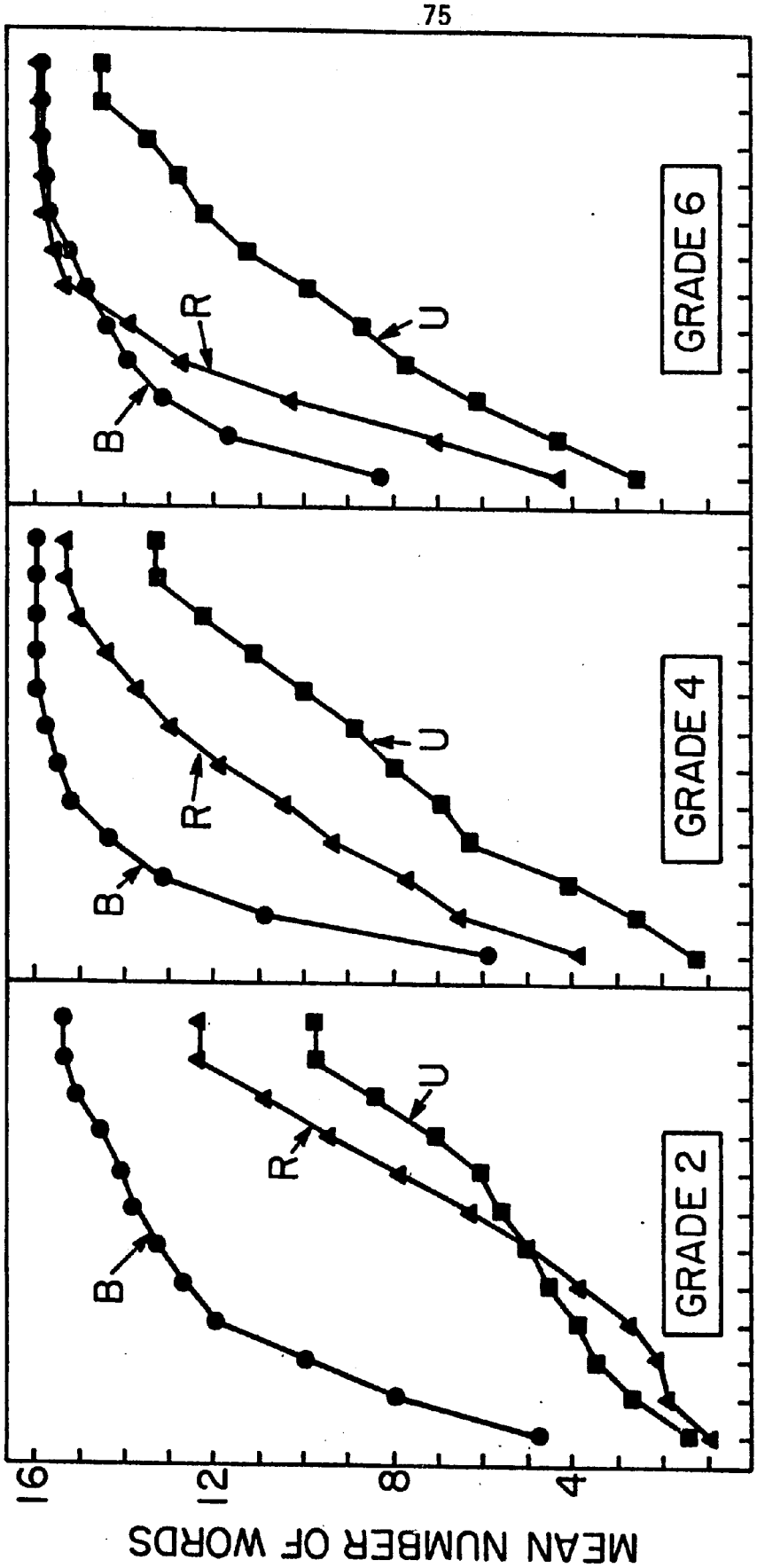


Fig. B. Mean number of words consistently retrieved from long-term memory (Consistent LTR) as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

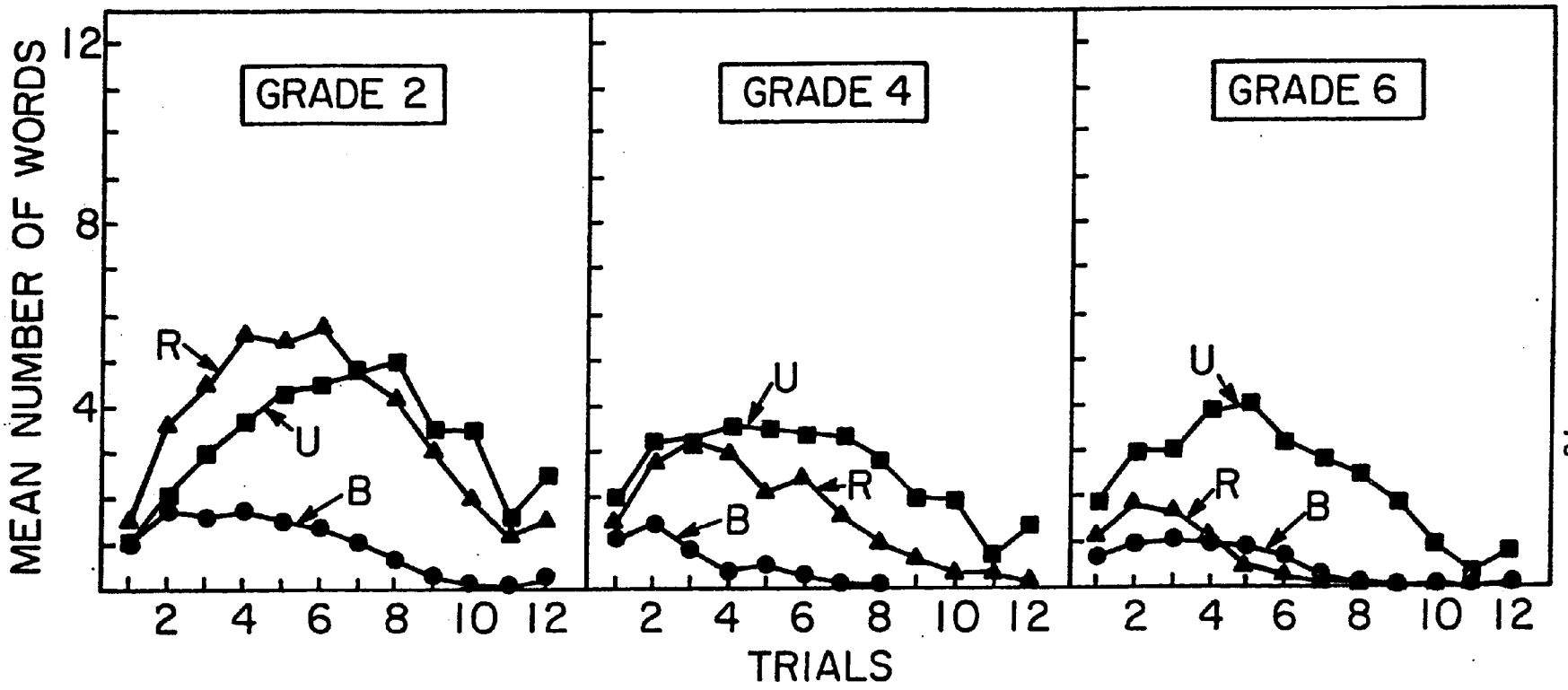


Fig. C. Mean number of words randomly retrieved from long-term memory (Random LTR) as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

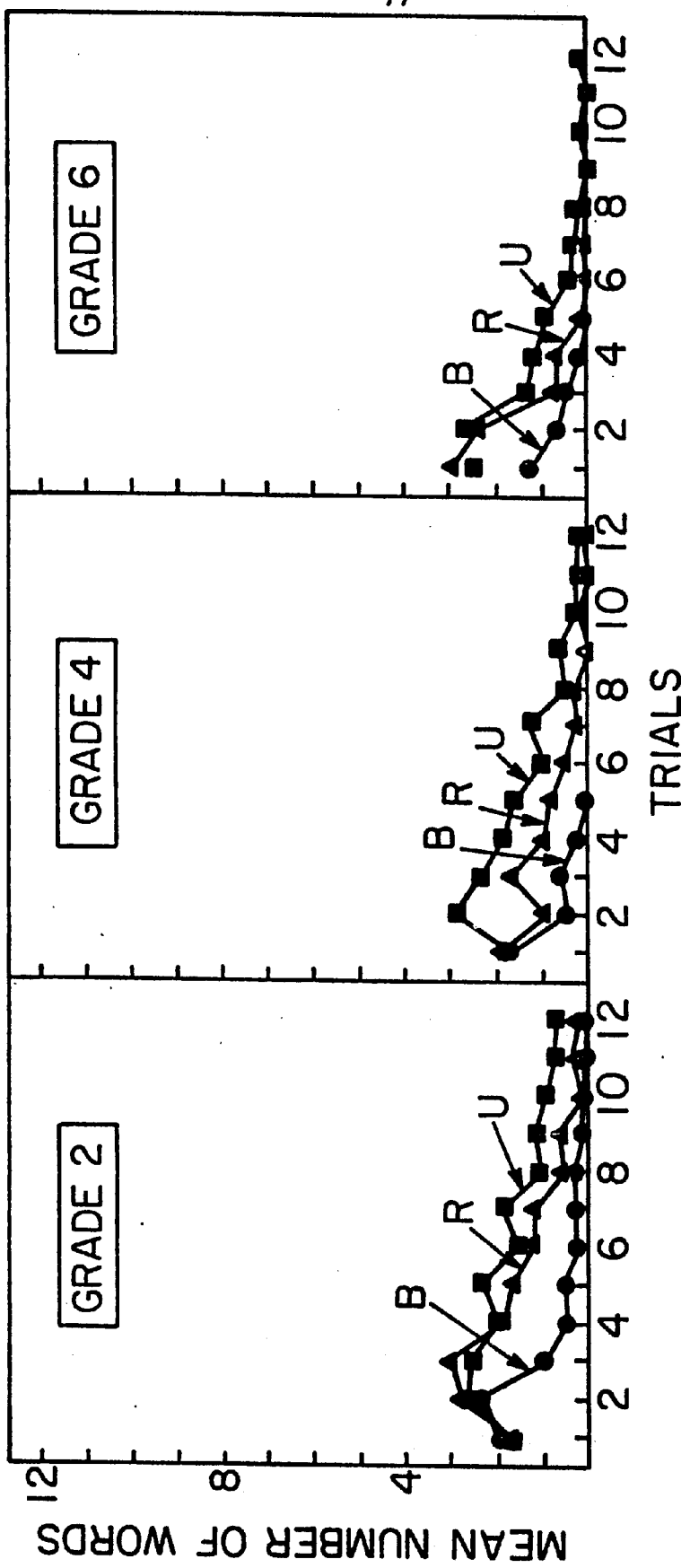


Fig. D. Mean number of words retrieved from short-term memory (STR) as a function of list type and trials; B-Blocked lists, R-Random lists, U-Unrelated lists.

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