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# The effects of temporal-spatial grouping on young children's recall.

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# THE EFFECTS OF TEMPORAL-SPATIAL GROUPING ON YOUNG CHILDREN'S RECALL

A Thesis Presented

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## Abstract

Two groups of children, two and four years of age, were presented with lists of words that were temporally-spatially grouped or ungrouped. It was hypothesized that temporal-spatial grouping would disrupt the recall of older children for these words and facilitate the recall of younger children. Contrary to these predictions, chunking hindered recall for both age groups, although the effect was less pronounced for younger children. Chunking, however, did produce differential effects on the manner in which words were recalled. Younger children recalled more last items in a chunk and more forward ordered pairs when they recalled first chunk items. Older children did not show such a tendency.

# Introduction

Most investigations of free recall in children have found that with increasing age, there is an increase in the number of items correctly recalled, as well as an increasing tendency to use some form of semantic organization of the to-be-remembered items. For example, it has been demonstrated that even very young children cluster items by category in their recall (Laurence, 1967; Rossi & Rossi, 1965) and that this use of categorical clustering increases significantly with age (Cole, Frankel, & Sharp, 1971; Mandler & Stephens, 1967; Moely, Olson, Hawles, & Flavell, 1969; Nelson, 1969; Rossi & Wittrock, 1971). Similarly, the tendency to use what has been termed subjective organization, ie., the subject's repetition of unrelated stimulus items in a consistent order from trial to trial, has also been shown to be positively related to age (Shapiro & Moely, 1971). Thus, the evidence suggests that organization based on conceptual or associative relationships among words is found in children. The question remains, however, as to whether there are other means of organization which young children can utilize as well, if not better, to facilitate their recall.

Three recent studies suggest that perhaps the physical attributes or relationships among stimulus items

may form the bases for organizational techniques that very young children use in their recall; that is, that acoustic or spatial arrangements of stimuli, as opposed to semantic content, may be quite salient to young children. In presenting children with lists of words that could be grouped by rhyming, semantic structure, or category, Rossi and Wittrock (1971) found that children with an MA of 2 years grouped words that rhymed together in their recall, whereas older children employed semantic structure or category clustering as bases for grouping stimulus items. Further evidence is provided by Kobasigawa and Middleton's (1972) study of the effects of category labeling and grouping on the recall of Kindergarden, third, and fifth grade children. All children displayed some degree of category clustering; however, more than any of the older subjects, Kindergarden children showed a marked tendency to recall items according to the rows in which they were presented. Finally, Lehman and Goodnow (1972) investigated the ability of children to reproduce rhythmic series in the form of patterns of pencil taps. When asked to indicate how they remembered the series, Kindergarden children were more likely to rely on a "song code," or temporal, rhythmic grouping, whereas older children used number codes which involved a reduction and recoding of the patterns into more conceptual terms. There is a strong suggestion from

these data, then, that the physical structure of a sequence of stimulus items may hold some particular significance for children of younger ages, although the limited number of studies that have been concerned with this question permit few generalizations as yet.

One procedure which capitalizes on the physical characteristics of stimulus presentation and which might affect the recall of young children is temporal grouping. In such a situation, sequences of stimulus items are broken down into auditory or spatial sub-groups, with an interim time or space between them. Skills in the perception and use of temporal groupings have been implicated as being important aspects of language development (Goldman-Eisler, 1968; Martin, 1970; Neisser, 1967; Rileigh & Odom, 1972; Zaporozhets & Elkonin, 1971) and it is plausible to suggest that temporal groupings may have salience as organizational features for children in other aspects of cognitive development.

The adult literature is replete with evidence that temporal grouping can be an efficient means of organization with respect to recall, at least when digits or letters are used as stimuli. Temporal grouping facilitates recall in adults when either auditory (Adams, 1915; Bower & Winzenz, 1969; Laughery & Spector, 1972; Ryan, 1969) or visual (Harris & Lown, 1968; Mayzner, Tresselt, Adler,

Cohen, & Schoenberg, 1966; Winzenz, 1972) presentation modes are used. When no grouping structure is provided by E, subjects still tend to impose their own temporal structure on a list, as is evidenced by the "hesitations" used in the learning of letter sequences by adult subjects in Belmont and Butterfield's study (1969). Explanations for the facilitative effects of temporal grouping on recall include the notion that intervals between groups allow for the rehearsal of items (Ryan, 1969) and the idea that the first items in a group may serve as "anchor points" for the recall of other items (Neisser, 1967). The general finding of multi-bowed serial position curves for grouped stimulus lists (Bower & Winzenz, 1969; Harris & Lown, 1968; Mayzner et al., 1966) seems to support this latter interpretation.

While temporal grouping does semm to have this facilitating effect on the recall of digits and letters, its influence on the recall of words is less clear. One of the few studies with adults where words were used showed that temporal grouping did not have the facilitative effect on total recall that has been demonstrated with other stimulus items (Gianutsos, 1971). Rather, grouping appeared to increase the recall of the last one or two groups in the stimulus list, while it deflated recall in the beginning of the list. One way of accounting for such

results is by an association hypothesis -- grouping may disrupt semantic associations among items, and thus, the S's own subjective organization for these items. This disruption might be particularly detrimental to recalling items in long-term storage, ie., those items in the early part of the list. Gianutsos discounts such a hypothesis on the grounds that there was no difference in the grouping effect when high and low frequency words were used as stimulus items. In arriving at her conclusion, Gianutsos assumed that low frequency words have less likelihood of generating semantic associations and thus would result in a greater chunking effect in recall. However, in adults, especially in the imaginative and verbal college students who comprised the subject population, even low frequency words might lead to very pronounced subjective organization. For example, Gorfein, Blair, and O'Neill (1969) found that even nonsense syllables (CVC's) produced subjective organization in their subjects. The prediction that there should be a difference between high and low frequency words may not, then, be a justified one, and the association hypothesis should not be rejected so readily.

One notion that may be rather circumspectly derived from these data is that grouping tends to disrupt semantic associations among list items where it is most beneficial to use them (ie., in long term memory storage

of words). Where it is more efficient not to rely on semantic organization (short term memory) or where there are no evident semantic associations (lists of digits or letters), temporal grouping is facilitative for recall. Following this line of reasoning, temporal organizing cues may be more salient to young children who do not display strong associative or subjective organization in recall.

Relatively few studies have investigated the influence of temporal grouping on children's recall or developmental changes in such effects. One group of experiments has focused on the relative effects of grouping on the recall of retarded and normal children, but the results have been equivocal. Spitz (1966), for example, found that visual and auditory grouping of digits raised the recall of retardates and normals. Moreover, the grouped recall of the retardates was at the same level as the ungrouped recall of normal children of comparable mental ages (8 to 10 years). Similarly, Harris (1972) found that grouping of digits resulted in better recall for both normal and retarded children with an MA of 8 years, although normals still displayed better recall than retardates in all conditions. On the other hand, MacMillan (1970) failed to find any effects of visual grouping of digits on the recall of his 8 to 10 year old sample of normal and retarded subjects. One possible reason for

this discrepancy, as MacMillan points out, may be that he did not require subjects to orally report the stimuli as they were presented, as these other studies did. At any rate, it appears that temporal grouping may have facilitative effects, at least on the recall of children who are 8 years of age or older, and where digits are used as stimuli.

Only two other studies have explored the possible influences of temporal grouping on the recall of even younger children. McCarver (1972) used a probe procedure with Kindergarden, first, and fourth graders, as well as college students, to see how instructional, temporal, and spatial cues of organization affected memory for familiar verbal items. Subjects in the experimental condition were specifically instructed to use temporal cues to diminish any tendency to use other means of organization. His findings were that only subjects 10 years of age or older were aided in their performance by the added cues. But a probe procedure does not actually give a measure of the organization that children do use, and in fact, may be relatively insensitive or even inappropriate as a measure of the facilitative effects of organization on memory for young children. As previously stated, the efficiency of chunking presumably lies in the notion that the first item of the group serves as some kind of "tagging" device and elicits the other items of the group in a

forward order (Gianutsos, 1971). In one experiment of the Gianutsos (1971) study, for example, the proportion of pairs recalled in forward order for the grouped condition was .72, while the figure for the ungrouped condition was .54. However, this notion of the efficiency of forward ordering in chunking is lost when a probe procedure is used because S is not, in fact, required to recall the item which would foster recall of subsequent items in a chunk. In order for chunking to facilitate memory for probed items, S's would need to determine the first item of a chunk and then locate the probe within that chunk. Although it is unclear how S's attempt to retrieve the probed item, it may be that older subjects are conducting a more systematic serial search. There is evidence to indicate that serial ordering in recall increases developmentally (Rossi & Wittrock, 1971). If this were the case, then it is more likely that older S's, assuming that they are carrying out a more systematic serial search, will retrieve the "tagged" item, and this would, in turn, facilitate recall for the location of the probed item. Hence, the superior performance of older subjects in the grouped condition may be a function of their more efficient serial search.

Harris and Burke (1972) have also conducted a developmental study of temporal-spatial grouping effects

on memory. Second, fourth, and sixth graders were presented with ungrouped, spatially grouped, and spatially-temporally grouped digits. It was found that spatial-temporal grouping did result in increased recall, particularly for the two older groups of children. The multi-bowed serial position curves indicated that the reason for this finding was because older children made better use of "anchor points" in the lists. It should be pointed out, however, that subjects in this experiment were told to recall digits in the order in which they were seen. This constrained recall situation may have resulted in higher levels of performance by older subjects, again because of their greater competence in serial search. Furthermore, the difference in age levels at which grouping facilitated recall between this study and McCarver's (1972) may in part be due to the fact that digits rather than words were used as stimuli, as well as methodological differences.

Perhaps a more informative way to study the organizational techniques that young children can and do use is through the use of the free recall paradigm. Presumably, the response protocols in such a situation would be more indicative of the organizational network that children construct. Accordingly, a pilot study was undertaken to ascertain what kind of organization children would use if stimulus items were grouped spatially,

temporally, and tonally. This last attribute was added to maximize the probability that subjects would notice the chunked form of the lists. Under these conditions, would children make use of the segmented structures in their recall, and would this in turn facilitate recall? These were the questions that were of primary interest in this preliminary investigation.

The subjects for this pilot study were 8 girls and 6 boys, ranging in age from 3 to 6 years. All children were enrolled in a day-care center program. Those children who were 3½ years old and under were designated "younger" subjects, while those over 3½ years were considered "older." There were seven members in each of these groups.

Stimulus lists consisted of 18 3½" X 4" pictures of familiar objects. The following two lists of nine items each were constructed with the constraint that there be no obvious semantic associations among the items within a list: List A: tree, cup, dress, car, dog, hand, girl, chair, cake; List B: star, key, fish, bed, shoe, boat, clock, door, bread. (Note: It should be pointed out, however, that there inadvertantly did appear the items "dress" and "girl" within List A.) Each list appeared as both grouped and ungrouped across subjects to control for effects of list difficulty. Chunks of three items were

used in the grouped conditions since this has been found to be optimal chunk size, at least for adults (Wickelgren, 1967).

Each child was presented with two lists, one grouped and one ungrouped, with an interval of one or more days between sessions to minimize interference effects. Half the subjects received the grouped list first and half the ungrouped list first to control for possible biases due to presentation order.

Subjects were tested individually. They were brought into a relatively quiet room in the day-care center and were told that they would be shown pictures of various items which they would later be asked to recall. For each of four trials, pictures were laid out in a horizontal line one by one while a voice on a tape recorder simultaneously labeled them. In the ungrouped condition, pictures were labeled at a rate of 1/sec and placed approximately 1" apart. In the grouped condition, pictures were labeled at a rate of 2/sec with a 2 sec interval between groups (making total presentation time approximately equal for both conditions). Pictures were placed right next to each other with approximately 3" between each group of three items. In addition, in the auditory labeling of the stimuli in this condition, each group was spoken in a different pitch to underscore the segmentation of

the list. Each item in the list remained in the same serial position across all trials and across subjects. Pictures were covered after each list presentation, and S's were asked to recall the pictures they had seen, after which they recieved a small trinket for "doing so well."

In general, it was found that grouping did result in slightly improved recall, although the difference between the two conditions was not significant. When the data were broken down by age, however, some interesting differences did emerge. For subjects 3½ years of age and older, grouping did not appear to have a facilitative effect on recall, the mean number of correct responses for four trials being 23.42 in the grouped condition and 24.14 in the ungrouped condition. However, for children under 3½ years of age, there was a tendency for grouping to improve recall. The mean number of correct responses here was 18.28 in the grouped condition and 15.00 in the ungrouped condition. Although this difference was not significant using a one-tailed correlated $t$-test ($t = 1.57$, $df = 12$) it did approach significance ($p < .10$).

Although no formal measure of clustering was taken, it did appear that subjects in the grouped condition were more likely to report the other two items from a chunk if they recalled one of the items. The most interesting aspect of the recall protocols was that several subjects

reported the items in sing-song groups of three, paralleling the presentation format.

These results, although not definitive, did suggest a trend -- that in a free recall situation, younger children are more apt to use temporal-spatial grouping than older children, and that the use of such a strategy facilitates their recall. In order to further explore this possibility, the experiment to be reported here was designed.

A few modifications of the pilot study were made. In order to separate the effects of temporal-spatial grouping from those of tonal grouping, four experimental conditions were included as within-subjects treatments -- tonal-chunked, tonal-nonchunked, nontonal-chunked, and nontonal-nonchunked. These conditions are described in more detail in the Method section. In addition, since it appeared in the pilot study that the critical age for the use of temporal-spatial grouping occurred at approximately 3 to 3½ years, it seemed reasonable that children in this age group or perhaps even younger should be included to compare with an older age group.

It was hypothesized that, as in the pilot study, the recall of younger children would be facilitated in both chunked conditions more than that of older children, for whom temporal grouping might disrupt other organizational

strategies, such as subjective organization. Furthermore, if the value of grouping lies in the subjects' use of "anchor points" or "tagging devices" to elicit the remainder of the chunk, then younger children should show high recall for these "anchor points" in the grouped conditions, as well as a high proportion of forward ordered pairs following them.

# Method

## Subjects

Thirty-two children, 16 between ages 2-6 and 3-0 years (mean age = 2-10 yr) and 16 between 4-6 and 5-0 years (mean age = 4-10 yr) served as subjects. There were equal numbers of males and females in each age group. Subjects in the younger age group were brought to the University of Massachusetts as part of a project on early cognitive development. Older subjects were all enrolled at a nursery school - Kindergarden, also in the Amherst area. Two boys and four girls in the younger age group and one girl in the older group were replaced because of failure to complete the task.

## Materials

The stimuli consisted of the following four lists of nine familiar items in pictorial form: List A: bell, kite, dog, girl, tree, pie, broom, hat, car; List B: plane, key, lamp, dress, cup, fire, cat, book, hand; List C: boat, fence, cake, horse, watch, leaf, comb, star, door; List D: fish, clock, house, truck, chair, flag, shoe, bread, spoon. Each picture card was 3½" X 4" in size. The lists were purposely constructed so that no obvious categorical or semantic relationships existed among the items.

Design and procedure

A 2 (age) X 2 (sex) X 2 (tonal condition) X 2 (chunking condition) factorial design was employed. Tonal and chunking conditions were presented on the form of the following within-subjects treatment groups:

1. Tonal-chunked (TC) - three temporal chunks of three words, each chunk being spatially grouped and labeled in a different tone.
2. Tonal-nonchunked (TNC) - a temporally and spatially ungrouped list where every three words were labeled in a different tone.
3. Nontonal-chunked (NTC) - three temporally and spatially grouped chunks of three words, each labeled in the same tone.
4. Nontonal-nonchunked (NTNC) - a temporally and spatially ungrouped list where each word was labeled in the same tone.

In the temporally-spatially ungrouped conditions (TNC and NTNC), stimulus pictures were presented one by one in a horizontal line in front of the child with approximately 1" between them. Simultaneous to their visual presentation, the pictures were labeled by a tape recording at a rate of 1/sec. In the temporally-spatially grouped conditions (TC and NTC), the pictures were laid out in the same fashion, but in groups of three with 3"

between groups and the pictures within a group lying right next to each other. The labeling rate was 2/sec with 2 sec between groups, making the total presentation time approximately equal for both conditions. In those conditions where there was tonal variation (TC and TNC), every three items were labeled in a different pitch. In the nontonal conditions (NTC and NTNC), the same pitch was used throughout a given presentation.

Chunks of three words were chosen for the grouped conditions since it seemed that subjects in the pilot study had no difficulty with units of that size. Tonality was included as a treatment to see if it would have any effects on recall, either alone or in combination with temporal-spatial grouping. All stimulus lists described above appeared in each of these experimental conditions to counteract possible differences in list difficulty.

All subjects were tested individually. Younger subjects were brought into a quiet experimental room at the Child Behavior Laboratory at the university, and were usually accompanied by a parent. Older subjects were tested in a relatively quiet area outside of their nursery school classroom. Single sessions consisted of four trials of presentation and recall of stimuli of a particular experimental condition, followed by a short break, and then a second series of four trials in another

experimental condition. Before the task was begun, children were told that they were going to play a game, and that they should look and listen to the objects presented, since they would be asked to remember them. After each presentation trial, the pictures were covered and the child was given 2 min to recall all the pictures he could, his attempt being rewarded with a small trinket.

Subjects in the two age groups were presented with each of the four experimental treatments on two separate days. This was done to minimize interference effects and also to make this a less protracted, tedious task for the children. To control for order of treatment effects, balance Latin square orders of presentation were used across subjects.

## Results

Analyses of the data were focused on three aspects in particular -- the mean number of words correctly recalled per trial, the serial position curves, and measures of clustering of items in recall.

### Words recalled per trial

All children recalled at least one item in each list, with the mean number of items remembered being 3.91. In general, the mean number of words recalled per trial was greater for older children ($\bar{X}$ = 4.68) than for younger children ($\bar{X}$ = 3.13). The nonchunked conditions resulted in better recall than the chunked conditions ($\bar{X}$ = 4.17 and 3.70, respectively), while the tonal conditions ($\bar{X}$ = 3.96) resulted in only slightly improved recall over the nontonal conditions ($\bar{X}$ = 3.86). Moreover, recall improved over trials ($\bar{X}$ = 2.78, 3.84, 4.42, and 4.59 for trials 1 to 4, respectively). A more complete listing of the mean number of words correctly recalled as a function of age, tonal condition, chunking condition, and trials is shown in Table 1.

To test for significance, a 2 (age) X 2 (sex) X 2 (tonal condition) X 2 (chunking condition) X 4 (trials) repeated measures analysis of variance (shown in Table 2) was computed. Significant main effects for age, $F(1, 28)$ =

Table 1

Mean number of words recalled as a function of age, condition, and trials

| Age | Younger | | | | | Older | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Trials | 1 | 2 | 3 | 4 | Over trials | 1 | 2 | 3 | 4 | Over trials | Over ages and trials |
| Condition | | | | | | | | | | | |
| Tonal-chunked | 1.87 | 3.13 | 4.00 | 3.63 | 3.16 | 3.00 | 4.44 | 4.44 | 5.56 | 4.36 | 3.76 |
| Nontonal-chunked | 2.44 | 2.94 | 3.25 | 3.19 | 2.95 | 3.06 | 4.13 | 4.88 | 5.31 | 4.34 | 3.65 |
| Tonal-chunked | 2.50 | 3.25 | 3.69 | 3.69 | 3.28 | 3.44 | 5.13 | 5.56 | 6.00 | 5.03 | 4.16 |
| Nontonal-nonchunked | 2.50 | 3.19 | 3.63 | 3.25 | 3.14 | 3.44 | 4.56 | 5.94 | 6.13 | 5.02 | 4.08 |
| Total over conditions | 2.33 | 3.13 | 3.64 | 3.44 | 3.13 | 3.23 | 4.56 | 5.20 | 5.75 | 4.69 | 3.91 |

Table 2

Analysis of variance for words recalled per trial

| Source of variance | df | MS | F | |
|---|---|---|---|---|
| Age (A) | 1 | 309.38 | 28.86 | **** |
| Sex (X) | 1 | 0.00 | 0.00 | |
| AX | 1 | 3.78 | 0.35 | |
| S(AX) | 28 | 10.72 | | |
| Tone (T) | 1 | 1.13 | 0.47 | |
| AT | 1 | 0.78 | 0.33 | |
| XT | 1 | 1.32 | 0.55 | |
| AXT | 1 | 0.38 | 0.16 | |
| ST(AX) | 28 | 2.39 | | |
| Chunk (C) | 1 | 21.95 | 9.11 | *** |
| AC | 1 | 8.51 | 3.53 | * |
| XC | 1 | 2.00 | 0.83 | |
| AXC | 1 | 0.50 | 0.21 | |
| SC(AX) | 28 | 2.41 | | |
| Trials (L) | 3 | 85.68 | 68.55 | **** |
| AL | 3 | 10.74 | 8.61 | **** |
| XL | 3 | 0.27 | 0.22 | |
| AXL | 3 | 2.18 | 1.74 | |
| SL(AX) | 84 | 1.25 | | |

Table 2 (continued)

| Source of variance | df | MS | F | |
|---|---|---|---|---|
| TC | 1 | 0.03 | 0.01 | |
| ATC | 1 | 0.03 | 0.01 | |
| XTC | 1 | 1.32 | 0.48 | |
| AXTC | 1 | 0.95 | 0.35 | |
| STC(AX) | 28 | 2.74 | | |
| TL | 3 | 1.40 | 1.41 | |
| ATL | 3 | 2.30 | 2.33 | |
| XTL | 3 | 0.15 | 0.15 | |
| AXTL | 3 | 0.97 | 0.98 | |
| STL(AX) | 84 | 0.99 | | |
| CL | 3 | 0.32 | 0.42 | |
| ACL | 3 | 1.40 | 1.86 | |
| XCL | 3 | 1.15 | 1.52 | |
| AXCL | 3 | 0.21 | 0.28 | |
| SCL(AX) | 84 | 0.75 | | |
| TCL | 3 | 0.62 | 0.93 | |
| ATCL | 3 | 0.72 | 1.09 | |
| XTCL | 3 | 2.84 | 4.29 | *** |
| AXTCL | 3 | 0.24 | 0.36 | |
| STCL(AX) | 84 | 0.66 | | |

Table 2 (continued)

| | |
|---|---|
| **** | Significant at the .001 level |
| *** | Significant at the .01 level |
| ** | Significant at the .05 level |
| * | Significant at the .07 level |

28.86, $p < .001$, chunking condition, $F(1, 28) = 9.11$, $p < .01$, and trials, $F(3, 84) = 68.55$, $p < .001$, were found in the directions described above. Further comparisons of the means for trials using the Newman-Keuls method revealed that the significant improvements in recall occurred between the third and fourth trials as compared to the first, $p < .05$.

Contrary to predictions, chunking did not facilitate the recall of young children. However, there was a tendency for chunking to interfere less with the recall of younger children than that of older children, as can be seen in the summary data shown in Table 3. The hypothesized age X chunking interaction was not as strong as predicted, attaining only marginal significance, $F(1, 28) = 3.53$, $p < .07$.

Also obtained were reliable interactions between age and trials, $F(3, 84) = 8.61$, $p < .001$, and sex X tonal condition X chunking condition X trials, $F(3, 84) = 4.29$, $p < .01$. The age X trials interaction can be attributed to the fact that older children improved more with practice than did younger children and continued to improve even on the last trial. Younger children dropped in performance on the last trial, a finding which may have resulted from the task being too long to sustain their attention and interest. No attempt to interpret the

Table 3

Mean words recalled per trial as a function of age and chunking condition

| | Age | |
|---|---|---|
| Condition | Younger | Older |
| Chunked | 3.06 | 4.35 |
| Nonchunked | 3.21 | 5.02 |

meaning of the four-way interaction was made here.

Serial position curves

Figure 1 shows the mean number of words recalled correctly over four trials as a function of age and serial position. The generally higher level of responding of the older children is not surprising. However, it should be noted that at least for the last serial position, the difference in recall between the two age groups is quite small, younger children recalling a mean of 2.31 words and older children recalling a mean of 2.34 words in that position. Furthermore, older children display a higher primacy effect relative to other portions of the serial position curve, while younger children show a higher recency effect. Within-groups multiple contrasts of serial position 9 versus the other eight positions indicated that for younger children, significantly more words were recalled in this last position than in any of the others. The *t*-values for these contrasts were 2.94, 5.20, 3.31, 2.84, 6.72, 4.47, 4.38, and 2.84 for positions 1 vs. 9, 2 vs. 9, etc., *df* = 15, EW $<$ .10. Such a strong recency effect was not found in the same analysis for older children.

The findings with respect to the mean number of words recalled as a function of age, tonal condition, chunking condition, and serial position are summarized in Table 4.

# FIGURE 1

Mean words recalled as a function of age and serial position (over 4 trials)

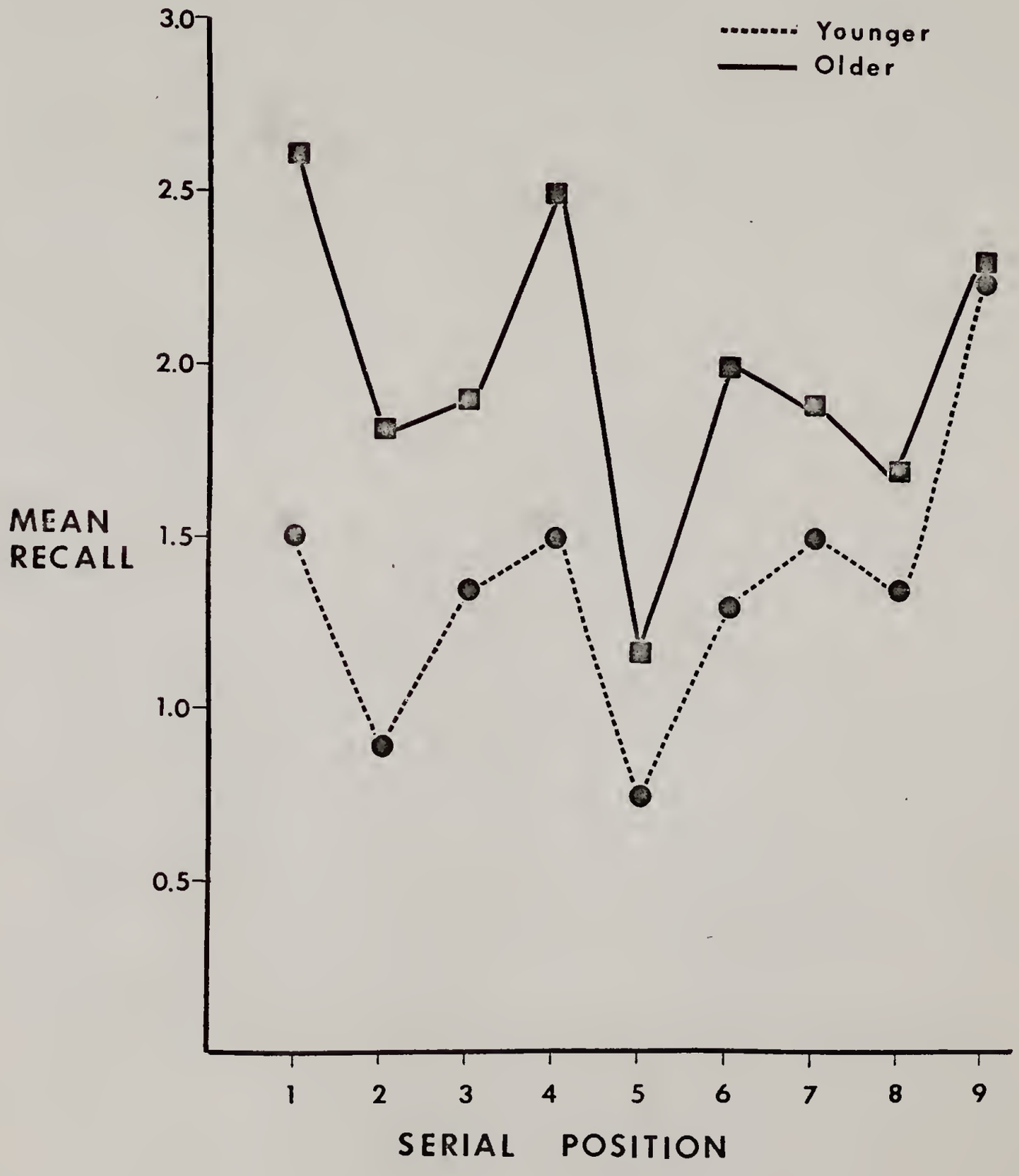


Table 4

Mean words recalled over four trials as a function of age, condition, and serial position

| Age | Condition | Serial position 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total over positions |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Y | TC | 1.13 | 0.81 | 1.56 | 1.13 | 0.44 | 1.88 | 1.50 | 1.63 | 2.56 | 1.40 |
| | NTC | 1.38 | 0.63 | 1.56 | 1.69 | 0.75 | 0.69 | 1.31 | 1.31 | 2.56 | 1.32 |
| | TNC | 1.88 | 0.94 | 1.38 | 1.50 | 0.81 | 1.31 | 1.50 | 1.31 | 2.50 | 1.46 |
| | NTNC | 1.63 | 1.00 | 1.13 | 1.69 | 1.00 | 1.38 | 1.75 | 1.44 | 1.63 | 1.40 |
| | Total over conditions | 1.50 | 0.84 | 1.41 | 1.50 | 0.75 | 1.31 | 1.52 | 1.42 | 2.31 | 1.40 |
| O | TC | 2.44 | 1.50 | 1.88 | 2.31 | 1.13 | 2.00 | 2.06 | 0.94 | 2.13 | 1.82 |
| | NTC | 2.44 | 1.88 | 1.75 | 2.69 | 0.88 | 2.06 | 2.19 | 1.19 | 2.06 | 1.91 |
| | TNC | 2.88 | 1.75 | 1.69 | 2.31 | 1.38 | 1.81 | 1.63 | 2.50 | 2.88 | 2.09 |
| | NTNC | 2.63 | 2.00 | 2.56 | 2.75 | 1.19 | 2.44 | 1.88 | 2.31 | 2.31 | 2.23 |
| | Total over conditions | 2.59 | 1.78 | 1.97 | 2.52 | 1.14 | 2.08 | 1.94 | 1.73 | 2.34 | 2.01 |
| | Total over age and conditions | 2.05 | 1.31 | 1.69 | 2.01 | 0.95 | 1.70 | 1.73 | 1.58 | 2.33 | 1.70 |

A 5-way repeated measures analysis of variance (age X sex X tonal condition X chunking condition X serial position) was used to test for significant effects. The results are listed in Table 5. Significant effects were found for age and chunking, as described above. Serial position was also a significant factor, $F(8, 224) = 11.75$, $p < .001$. There was also a tendency for more words to be recalled in the final serial position than any of the others, although Newman-Keuls comparisons yielded no significant contrasts among these means.

In addition, there was a significant age X position interaction, $F(8, 224) = 2.27$, $p < .025$, and an age X chunking condition X position interaction, $F(8, 224) = 2.09$, $p < .05$. As stated above, the age X position interaction seems to stem from the within-groups difference in recall between position 9 and the other positions for younger children, while such a difference was not exhibited by older children. Multiple contrasts between age groups were also done, but showed no significant differences for any serial position. As Figure 2 shows, the three-way interaction seems to be due to the tendency for younger children to recall the last word in a chunk in the chunked conditions, while older children tend to recall the first word in a chunk in that condition. In contrast to the chunked conditions, the recall patterns for both age groups seemed to be relatively similar to each other in the nonchunked

Table 5

Analysis of variance for words recalled over four trials

| Source of variance | df | MS | F | |
|---|---|---|---|---|
| Age (A) | 1 | 108.78 | 19.87 | ***** |
| Sex (X) | 1 | 1.53 | 0.28 | |
| AX | 1 | 0.00 | 0.00 | |
| S(AX) | 28 | 5.48 | | |
| Tone (T) | 1 | 0.13 | 0.05 | |
| AT | 1 | 2.35 | 0.87 | |
| XT | 1 | 0.13 | 0.05 | |
| AXT | 1 | 0.35 | 0.13 | |
| ST(AX) | 28 | 2.70 | | |
| Chunk (C) | 1 | 9.75 | 9.20 | **** |
| AC | 1 | 3.78 | 3.57 | * |
| XC | 1 | 0.78 | 0.74 | |
| AXC | 1 | 0.28 | 0.27 | |
| SC(AX) | 28 | 1.06 | | |
| Serial position(P) | 8 | 21.52 | 11.75 | ***** |
| AP | 8 | 4.16 | 2.27 | *** |
| XP | 8 | 1.18 | 0.64 | |
| AXP | 8 | 1.47 | 0.80 | |
| SP(AX) | 224 | 1.83 | | |

Table 5 (continued)

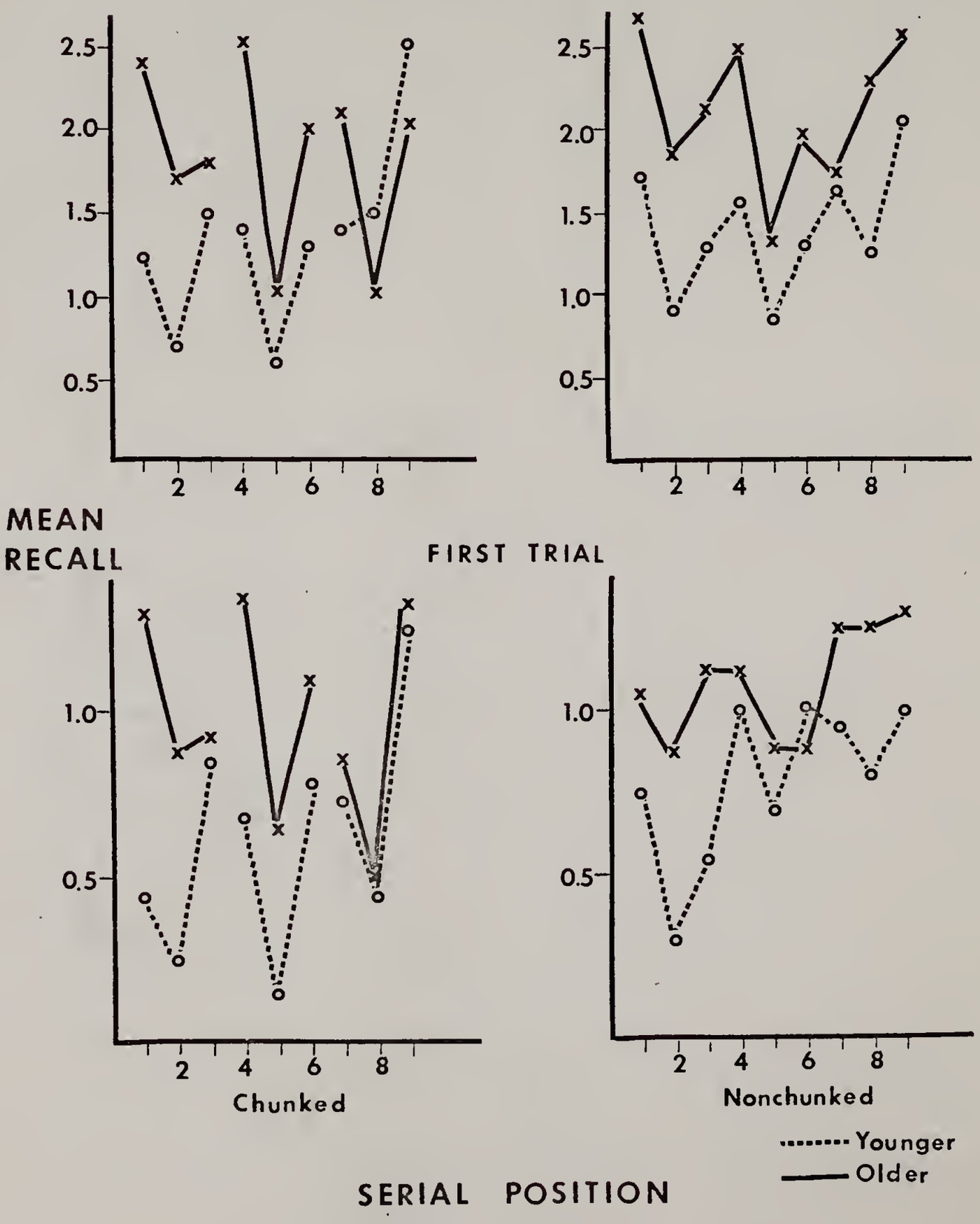
| Source of variance | df | MS | F | |
|---|---|---|---|---|
| TC | 1 | 0.13 | 0.10 | |
| ATC | 1 | 0.01 | 0.01 | |
| XTC | 1 | 0.89 | 0.73 | |
| AXTC | 1 | 0.22 | 0.18 | |
| STC(AX) | 28 | 1.22 | | |
| CP | 8 | 1.64 | 1.01 | |
| ACP | 8 | 3.40 | 2.09 | ** |
| XCP | 8 | 1.75 | 1.01 | |
| AXCP | 8 | 1.04 | 0.64 | |
| SCP(AX) | 224 | 1.63 | | |
| TP | 8 | 1.40 | 0.90 | |
| ATP | 8 | 1.21 | 0.78 | |
| XTP | 8 | 1.91 | 1.22 | |
| AXTP | 8 | 2.45 | 1.58 | |
| STP(AX) | 224 | 1.56 | | |
| TCP | 8 | 1.67 | 1.06 | |
| ATCP | 8 | 0.87 | 0.55 | |
| XTCP | 8 | 0.83 | 0.53 | |
| AXTCP | 8 | 1.83 | 1.17 | |
| STCP(AX) | 224 | 1.57 | | |

Table 5 (continued)

| | |
|---|---|
| ***** | Significant at the .001 level |
| **** | Significant at the .01 level |
| *** | Significant at the .025 level |
| ** | Significant at the .05 level |
| * | Significant at the .10 level |

# FIGURE 2

Mean words recalled as a function of age, condition, and serial position



treatments. Added mention of these nonchunked response patterns should be made here, since they are not typical serial position curves, where there is usually moderate recall of the first few items, decreased recall of middle items, and finally, high levels of recall for the last few items. Instead, the curves illustrated here appear uncharacteristically irregular -- almost as if recall was chunked. One possible explanation for such patterns of recall is that presentation of chunked lists may have biased how subjects recalled nonchunked lists. Consequently, the recall protocols for first trial data for the first condition presented were graphed, and are also shown in Figure 2. For the chunked conditions, the trend described above is even more apparent -- younger children recalled more last words and older children more first words in a chunk. More importantly, though, the first trial data for the nonchunked conditions shows that once again, the serial position curves are atypical for both age groups. Thus, it seems that presentation order biases may not be as responsible for the atypical curves as other factors, possibly some sort of subject-imposed organization on the list.

The differences in response patterns between the two groups of subjects in the chunked conditions seemed to be interesting enough to warrent further analysis. Therefore,

recall of the first item in a chunk was compared to recall of the second and third items in a chunk. When these data are broken down according to treatment conditions, as in Figure 3, it can be seen that in the nonchunked conditions, both groups of children recalled the first and third items equally well and better than the second. In the chunked conditions, younger children recalled the last item most, while older children recalled the first. For all children, all positions were significantly different from each other. A 5-way repeated measures analysis of variance (age X sex X tonal condition X chunking condition X position in chunk) was done to test for significant effects and the findings are listed in Table 6. The age and chunking conditions main effects found previously were significant, as well as position in chunk, $F(2, 56) = 33.57$, $p < .001$. In answer to the main focus of this analysis, there was a significant age X position X chunking condition interaction, $F(2, 56) = 3.60$, $p < .05$, indicating that, as mentioned above, more words in the last position in a chunk in the chunked conditions were recalled by younger children, while older subjects recalled more words in the first position in that condition. However, because this tendency of younger children to recall the last item in a chunk occurred consistently in only two chunks (see Figure 2 where position 4 recall exceeds position 6), it may be that the source of

## FIGURE 3

Mean words recalled as a function of age, condition, and position in a chunk (over 4 trials).

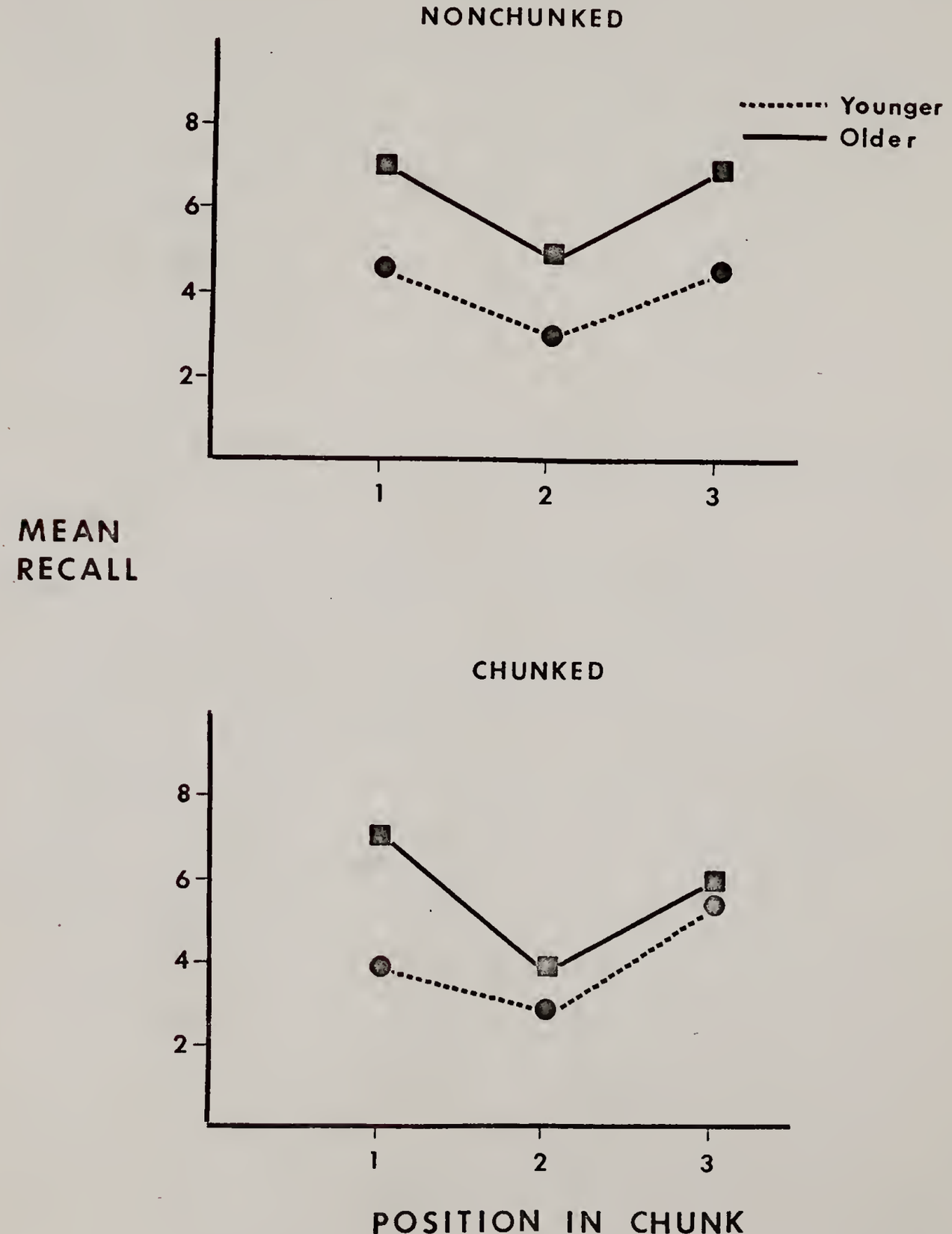


Table 6

Analysis of variance for position in a chunk

| Source of variance | df | MS | F | |
|---|---|---|---|---|
| Age (A) | 1 | 322.67 | 22.18 | **** |
| Sex (X) | 1 | 3.38 | 0.23 | |
| AX | 1 | 1.04 | 0.07 | |
| S(AX) | 28 | 14.55 | | |
| Tone (T) | 1 | 2.04 | 0.34 | |
| AT | 1 | 1.50 | 0.25 | |
| XT | 1 | 0.00 | 0.00 | |
| AXT | 1 | 1.50 | 0.25 | |
| ST(AX) | 28 | 6.01 | | |
| Chunk (C) | 1 | 17.51 | 5.67 | *** |
| AC | 1 | 8.76 | 2.83 | |
| XC | 1 | 2.34 | 0.76 | |
| AXC | 1 | 0.01 | 0.00 | |
| SC(AX) | 28 | 3.09 | | |
| Position (P) | 2 | 158.95 | 33.57 | **** |
| AP | 2 | 12.64 | 2.67 | * |
| XP | 2 | 5.34 | 1.13 | |
| AXP | 2 | 0.51 | 0.11 | |
| SP(AX) | 56 | 4.73 | | |

Table 6 (continued)

| Source of variance | df | MS | F | |
|---|---|---|---|---|
| TC | 1 | 0.09 | 0.02 | |
| ATC | 1 | 0.09 | 0.02 | |
| XTC | 1 | 3.76 | 1.10 | |
| AXTC | 1 | 0.09 | 0.02 | |
| STC(AX) | 28 | 3.43 | | |
| PT | 2 | 6.29 | 1.69 | |
| APT | 2 | 3.03 | 0.82 | |
| XPT | 2 | 4.63 | 1.24 | |
| AXPT | 2 | 1.53 | 0.41 | |
| SPT(AX) | 56 | 3.72 | | |
| PC | 2 | 6.64 | 2.13 | |
| APC | 2 | 11.20 | 3.60 | ** |
| XPC | 2 | 0.66 | 0.21 | |
| AXPC | 2 | 10.14 | 3.26 | ** |
| SPC(AX) | 56 | 3.11 | | |
| TCP | 2 | 2.63 | 0.90 | |
| ATCP | 2 | 2.28 | 0.78 | |
| XTCP | 2 | 0.54 | 0.19 | |
| AXTCP | 2 | 2.34 | 0.80 | |
| STCP(AX) | 56 | 2.92 | | |

Table 6 (continued)

| | |
|---|---|
| **** | Significant at the .001 level |
| *** | Significant at the .025 level |
| ** | Significant at the .05 level |
| * | Significant at the .10 level |

this interaction lies elsewhere. It may, in fact, be more directly the result of the sizeable recency effect that younger children display in position 9 of the chunked conditions. This consideration makes it difficult to make any strong, conclusive statements concerning the effects of chunking on younger childrens' recall patterns.

Clustering measures

A third focus of interest was to see if temporal-spatial grouping affected how lists were recalled, in addition to the amount recalled. Presumably, the serial position curves yielded some of this information. But it was thought that the use of more formal measures of clustering in recall would be even more informative. The first measure applied to the recall scores was Bousfield's (1953) Ratio of Repetition, which seemed to be most appropriate for developmental data (Frender & Doubilet, 1974). Unchunked lists were divided into groups of three categories for the purposes of comparison. The Ratio of Repetition is calculated as follows :

$$RR = \frac{NP}{N - 1} - \frac{e - 1}{ce - 1}$$

where NP = the number of pairs of successive items from the same category,

N = the number of words recalled,

e = the number of exemplars of each category in the list presented, and

c = the number of categories in the list presented. There is no set upper limit to indicate perfect clustering in this RR measure, but chance clustering is denoted by a score of zero. Both younger and older subjects clustered recall above chance level, the mean RR score being 0.05, $F(1, 28) = 6.89$, $p < .025$. How this finding is to be interpreted, though, remains unclear, since the RR scores themselves were quite low. Significance of these RR scores may be a reflection of the use of serial recall by subjects.

A listing of the RR scores as a function of age, condition, and trials (shown in Table 7) shows that there is a slight tendency for older subjects to cluster more than younger children and for clustering to increase over trials 1 to 3. However, an analysis of variance on these scores yielded no significant effects.

It should be pointed out that the RR includes the restriction that successive pairs of repetitions be used in calculating the amount of clustering. This might be too severe a restriction and information might be lost concerning organizational structures in recall. To circumvent this problem, another approach was used to study the organization of recall protocols -- the calculation of the number of forward ordered pairs given the condition

Table 7

RR scores as a function of age, condition, and trials

| | | Trials | | | | |
|---|---|---|---|---|---|---|
| Age | Condition | 1 | 2 | 3 | 4 | Total over trials |
| Y | TC | -0.16 | 0.06 | 0.03 | 0.02 | -0.01 |
| | NTC | 0.03 | 0.08 | 0.03 | -0.02 | 0.03 |
| | TNC | -0.13 | 0.07 | 0.03 | 0.13 | 0.03 |
| | NTNC | -0.03 | -0.03 | 0.18 | 0.08 | 0.05 |
| | Total over conditions | -0.07 | 0.04 | 0.07 | 0.05 | 0.02 |
| O | TC | 0.04 | 0.14 | 0.21 | 0.13 | 0.13 |
| | NTC | -0.09 | 0.03 | 0.03 | 0.07 | 0.01 |
| | TNC | -0.05 | 0.06 | 0.18 | 0.15 | 0.08 |
| | NTNC | 0.13 | 0.03 | 0.02 | 0.06 | 0.06 |
| | Total over conditions | 0.01 | 0.06 | 0.11 | 0.10 | 0.07 |
| | Total over age and conditions | -0.03 | 0.05 | 0.09 | 0.08 | 0.05 |

that the first item of a chunk was recalled. Also, the number of backward ordered pairs given recall of the last item in a chunk was calculated since younger subjects tended to recall last items. As before, unchunked lists were divided into chunks of three so that comparisons could be made among the treatment groups. Because of the confounding factor of older children recalling more first and last words in a chunk, these data were treated as proportions. Furthermore, forward ordered pairs were scored as including not only successive pairs (such as the response pattern 1 2 _), but also response patterns 1 _ 2, and 1 _ 3. Backward ordered pairs were scored similarly. The proportion of forward and backward ordered pairs given recall of the first and last item in a chunk, respectively, is shown in Table 8, along with the mean number of words recalled in the appropriate condition. The most striking feature of these data is that given the recall of the first item in a chunk in the chunked conditions, younger children recalled relatively more forward ordered pairs than did older children. In the nonchunked conditions, however, both groups of subjects recalled about the same proportion of forward ordered pairs. Thus, chunking did influence to some extent the manner in which words were recalled by younger children, if not the amount. With regard to backward ordered pairs,

Table 8

Conditional proportions of pairs recalled as a function of age and condition

| Age | Younger | | | | Older | | | |
|---|---|---|---|---|---|---|---|---|
| Condition | TC | NTC | TNC | NTNC | TC | NTC | TNC | NTNC |
| Proportion of forward ordered pairs recalled given recall of first item of chunk | .45 | .41 | .36 | .16 | .37 | .19 | .31 | .23 |
| Proportion of backward ordered pairs recalled given recall of last item of chunk | .12 | .19 | .22 | .23 | .19 | .20 | .20 | .23 |
| Mean words recalled | 3.15 | 2.95 | 3.28 | 3.13 | 4.36 | 4.34 | 5.03 | 5.02 |

both age groups recalled fewer of these across conditions.

Intrusion errors

One final aspect of the recall protocols which was inspected was the number of intrusion errors made by subjects regarding both words from previous list presentations and words not appearing in any stimulus list. As expected, younger children made more intrusion errors than did older children (54 vs. 17). However, both groups made the same number of errors involving words extraneous to the stimulus lists (4 in each group). The difference lies, therefore, in the number of intrusions from previously presented stimulus lists, younger children making more of this type of error than older children. An analysis of variance with age, sex, tonal condition, chunking condition, and trials as factors was performed on these intrusion scores to see if there was any systematic variation, but none was found.

## Discussion

The present study was designed to explore the effects of temporal-spatial organizational cues on the recall of young children. In particular, it was hypothesized that young children, 2 to 3 years of age, might be especially attuned to the physical structures (both rhythmic and auditory) of stimuli, and would have a predisposition to use such structures in cognitive tasks such as the free recall situation. On the other hand, it was thought that older children, 4 to 5 years of age, who have more experience and facility with language and thinking in terms of language, might be more semantically oriented in confronting cognitive tasks. For these children, an imposed physical structure on a list of words to be recalled might not be beneficial; in fact, it might be disruptive since the child's subjective organization of the list might be interfered with.

In terms of the number of words recalled in each of the treatment conditions, the findings of this investigation did not strongly support the above hypothesis. That is, chunking did not facilitate the recall of the younger age group. Chunking, in fact, had a detrimental effect on the recall of both groups of subjects, although the magnitude of this effect was slightly less for

younger children. This finding that the recall of children 5 years of age and younger is not facilitated by temporal organization is consistent with the results of several other investigations (Harris & Burke, 1972; MacMillan, 1970; McCarver, 1972).

There are a few possible explanations for the above results. First, it could be that both older and younger subjects were using some sort of subjective organization and the temporal-spatial grouping was disrupting this organization. Younger subjects may have been just beginning to use subjective organization, so that the effects of grouping may not have been quite so disruptive. But there is no evidence in the literature to support such a notion. Unfortunately, because stimulus lists were presented in the same order to each subject on each trial, it was impossible to obtain a measure of subjective organization to investigate this interpretation.

A second possibility is that temporal-spatial cues are simply not salient as organizational features for young children, and that only later on in development, if at all, do they take on any significance as potential means for mediating recall. Even in adults, the potency of temporal grouping in facilitating overall recall of words is questionable (Gianutsos, 1971). It may be that

temporal grouping is influential only when stimuli are digits, or other less complex and meaningful stimuli.

Despite the fact that levels of recall were not facilitated by chunking, it would be misleading to discount its effect on recall at all. More specifically, from the data on conditional probabilities of recall of forward ordered pairs given recall of the first item of a chunk (from Table 8), it would appear that chunking does indeed have an effect beyond disruption of recall for older children. For 2 year olds, this effect is apparently not on the number of words recalled, but on how the words are recalled. Younger children recalled a much higher proportion of forward ordered pairs in the chunked conditions than did older children, given recall of the first item of a chunk. In that sense, chunking can be said to have quite a significant influence on recall. It seems that if 2 year olds remember that first "anchor point," they do reasonably well in remembering the rest of the items in a chunk.

If younger children recall more forward ordered pairs in the grouped conditions, why, then, is their recall not facilitated? An obvious answer is that they are not recalling as many first items as older children, as can be seen in the serial position curves. If chunking is to facilitate recall by providing "anchor points" or "tagging devices" that serve as mediators for the rest of

the stimulus list, then these "anchor points" must be encoded and retrieved as such. Apparently, younger children are not doing this; they instead seem to focus on the last words in a chunk. The implication is that if younger children were to encode and use the "anchor points," their recall of the rest of the list would be greatly enhanced.

This inclination of the 2 year olds to recall last items, especially in the chunked conditions, is one of the more notable features of the data. For example, the age X serial position interaction described above seems to be the result of the generally poorer recall of 2 year olds for all serial positions except the last, where it climbs to the same level. The age X chunking condition X serial position interaction and the age X chunking condition X position in chunk interaction likewise reflect the tendency for younger children to recall the last item of a chunk most (for two out of three chunks), although this effect may also have been caused by the enormous recency effect for the last item. Yet the first trial data presented in Figure 2 underscores this notion of chunking enhancing the recency effect for the three temporal-spatial groups -- it is almost as if 2 year olds react to the chunks as three separate lists. Had the recall of item 6 been slightly higher for younger children in the chunked conditions, a stronger

statement could be made regarding the dominant role of recency in the chunked lists. At this point, however, the most appropriate conclusion would be that 2 year old children show quite a strong recency effect in free recall (a finding also reported by Perlmutter, Benson, & Myers, 1973), and this recency effect is augmented by temporal-spatial grouping.

If one were to characterize the memory mechanisms of 2 year olds in speculative terms based on these findings, one might say that in some sense, 2 year old children have a largely sensory-based short-term memory store. The recency effects at the end of the chunked lists, coupled with the forward ordered recall lend some credence to such a notion. Of course, such conclusions are highly tentative, but do deserve further exploration.

Older children may also notice the temporal-spatial grouping cues, but their recall seems to be hindered by them, perhaps because they may be more inclined to use semantic organization of the words in the list. Even though there was no measure of subjective organization of the recall responses, the fact that older children had higher recall in the nongrouped conditions, but not a higher proportion of forward ordered pairs points in this direction.

Aside from affecting the amount of recall, chunking also appears to have an effect on how older children recall words that is different from its effect on younger children. Four year olds do slightly better on first items in a chunk, even over-riding the recency effect for the last chunk. The first trial data in Figure 2 also partially reflect this tendency. Furthermore, in the chunked conditions, given recall of the first item in a chunk, older subjects did not recall as many forward ordered pairs as younger children. As in the nonchunked conditions, this latter finding may be indicative of some subjective organization being used by these subjects. The emphasis on first items in a chunk might be better understood in the framework of Flavell's (1971) discussion of memory development. Changes in children's ability to recall are viewed by Flavell as a result of an incrwasing awareness on the part of the child of himself as a learner and memorizer. Thus, a 4 year old child who is told to remember the words in a list may be focusing on the first words in a chunk and actively rehearsing them rather than the chunk during the presentation of the rest of the list items. This may account for the drop in performance in positions 2 and 5 in the chunked lists. Thus, in 4 year olds, short-term memory may be less of a sensory store, and more of a rehearsally-oriented semantic store.

These data may also pertain to Harris and Burke's (1972) interpretation of developmental changes in the effects of temporal grouping. These investigators point out that older children perform more successfully in the grouped condition of their experiment because they made better use of "anchor points" in the list. The data reported here indicate that it is not the recall of words after "tags" that older children are more proficient at (even 2 year olds seem to be relatively capable of that), but the recall of the "tags" themselves. Again, this may be a reflection of older children's greater awareness and use of rehearsal strategies in recall.

One interesting phenomenon which occurred during pilot testing and which was not observed in this study, with one exception, was the "sing-song" repetition of stimulus lists by young children, mimicing the mode of presentation by the experimenter. It could be that a day-care setting, where the pilot testing was done, is more conducive to children's free, uninhibited responding. Songs are usually sung quite frequently in day-care and nursery school situations -- and subjects may have been more likely to do the same in that setting. The laboratory situation, however, where the child is interacting with a stranger in an unfamiliar setting, with no other children around, may have inhibited such "sing-song"

responding.

Most of the other findings in this study were not surprising. Older children improved more with practice. This is to be expected of children who are at an age where they are learning to learn. Also, tonal variation by itself did not seem to have a pronounced effect on recall. Rather, the grouping of words in terms of distinct rhythmic chunks seemed to be the more significant factor in influencing responding.

In conclusion, the major finding of this study was that temporal-spatial grouping of words did not improve the recall of young children, but hindered it. This effect was less pronounced for 2 year olds than for 4 year olds. Differences did emerge, however, in the way in which chunking affected how words were recalled by the two age groups. Younger children tended to recall last items in chunked groups and recalled more forward ordered pairs when they recalled first chunk items. In contrast, older children tended to recall first items and fewer forward ordered pairs following them. These differences in the effects of chunking on the manner of recall may be a function of different strategies and memory mechanisms between younger and older children.

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