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GENERALIZATION OF INSTRUCTED REHEARSAL STRATEGIES IN DEAF CHILDREN

by

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ABSTRACT

Research has shown that the performance of deaf children on memory tasks is usually inferior to that of hearing children. This deficiency is usually attributed to limitations in symbolic behavior in the deaf. Furthermore, it has been demonstrated that training deaf adolescents to actively rehearse increases their memory performance. The present experiment studied the effects of a repetitive naming rehearsal strategy on the memory performance of manually trained deaf children. In addition, the generalization of rehearsal behavior to new test items was assessed both immediately following training and after a ten day delay. An attempt to facilitate generalization using the method of training sufficient exemplars was included by training one-half the subjects in each rehearsal condition on four lists of pictures, while training the remaining subjects on only one list.

Sixteen younger (mean age = 7 years, 6 months) and sixteen older (mean age = 12 years, 9 months) deaf children served as subjects in a position probe recall task using lists of familiar pictures. In the first training session, subjects were randomly divided into rehearsal and no rehearsal conditions. Rehearsal subjects were told to sign the name of the picture and to continue signing until the next picture was presented. The rehearsal subjects were also prompted to rehearse in this manner during the picture probe task. In the first phase of session 2, one-half the subjects in each rehearsal condition received further training trials on List 1 (single list training) and the other subjects received the

same number of training trials on three new lists (multilist training). The second phase of session 2 consisted of an immediate generalization test; a new set of pictures was presented without rehearsal instructions or prompting. The third session, given 10 days later, provided a delayed generalization test.

With respect to recall performance, analyses revealed that the rehearsal subjects performed significantly better than the no rehearsal subjects during rehearsal training. Furthermore, on both the immediate and delayed generalization tests, rehearsal subjects continued to perform at a higher level than control subjects. Serial position analyses indicated that the rehearsal strategy was effective in enhancing recall performance at all positions. This indicates that repetitive naming rehearsal improved both short and long-term storage.

Six of the eight younger subjects and four of the eight older subjects maintained their repetitive naming behavior in both the immediate and delayed generalization tests, while the two remaining younger subjects and three additional older subjects named the pictures when they were presented but not during the interitem interval. None of the no rehearsal children repetitively named the pictures and only one younger and two older no rehearsal subjects named the items. The number of training lists had no effect on accuracy of recall or the amount of generalized rehearsal.

It is evident that sign language rehearsal training not only increases memory performance in manually trained deaf children, but that such behavior can become generalized over time, and to new test items.

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INTRODUCTION

Rehearsal is one type of mnemonic strategy that has been found to increase memory retention in children and adolescents (Belmont, Karchmer & Pilkonis, 1976; Keeney, Cannizzo & Flavell, 1967; Kingsley & Hagen, 1969; Kurtz & Hovland, 1953). Rehearsal can range from simply producing a verbal label for a stimulus item, either overtly or covertly, to cumulative rehearsal. The labelling of items is often referred to as 'naming', and this procedure can also be extended to continuous or 'repetitive naming' (Allik & Siegel, 1976). Cumulative rehearsal refers to the continuous, additive repetition of all items to be learned.

According to Weist and Crawford (1977), rehearsal appears to have two functions which are adaptive under different memory conditions. These functions have been called 'maintenance' and 'recoding'. Repetition of item names maintains them in short-term storage, while making use of relationships that exist among items organizes and recodes them in such a way as to facilitate long-term storage. When relatively few items have to be remembered for a short period of time, the maintenance function is most appropriate. Longer lists, or items that must be remembered over time, probably require the recoding function in order to retain the information.

Memory researchers have argued that the natural development of rehearsal processes facilitates the memory capabilities of children (Flavell, 1970), and many studies have been conducted to test this hypothesis. Kurtz and Hovland (1953) experimentally manipulated verbalization

with hearing children, in a study designed to test the prediction that naming would improve the accuracy of retention, a finding previously noted by Barlow (1928) in a study that investigated the role of articulation in memorizing. These authors reported that accuracy of retention was increased by verbalization at the time of stimulus observation.

Other studies that have looked into the role played by various rehearsal strategies (Flavell, Beach & Chinsky, 1966; Keeney, Cannizzo & Flavell, 1967; Kingsley & Hagen, 1969) have demonstrated that very young children (nursery school and kindergarten), and mentally retarded children of all ages (Belmont & Butterfield, 1971; Brown, Campione & Murphy, 1974; Kellas, Ashcraft & Johnson, 1973), do not make use of rehearsal strategies. These children can, however, be taught to verbally label stimuli in serial tasks, and thus improve their performance. These studies also show that verbal rehearsal can be an effective strategy to employ when lists of familiar or namable items are to be held in memory for short periods of time. It has been found that in serial tasks performance on the last serial position is facilitated by naming the items while performance on middle and early serial positions is facilitated by cumulative rehearsal during stimulus presentation (Kingsley & Hagen, 1969). This more complex form of rehearsal is not usually found in young children (Flavell, Beach & Chinsky, 1966; Keeney, Cannizzo & Flavell, 1967).

It has been shown that serial recall exhibits a developmental increase in accuracy, possibly caused by a lack of appropriate rehearsal strategies in very young children (Reese, 1976). It appears that in

young children it is the quantity of rehearsal that is linked to retention (Weist & Crawford, 1977) but for older children this may not be the case. The superiority of older children (sixth grade) in contrast to younger ones (third grade) was studied by Naus, Ornstein and Aivano (1977). These authors discovered that this superior performance resulted from the older child's enhanced recall of the beginning (primacy) and middle items, as there were minimal age differences in the recall of items from the last (recency) positions.

Past studies have tended to agree that the performance of the deaf on memory tasks is inferior to that of the hearing (Belmont, Karchmer & Pilkonis, 1976; Pintner & Paterson, 1917; Wallace & Corballis, 1973). Furth (1964) in his review of research with the deaf, concluded that the deaf are intellectually handicapped because they lack the free use of language, and Pintner and Paterson (1917) suggested that the deaf's inability to verbalize might account for their poor performance, as they are prevented from acquiring acoustic imagery. Hiskey (1956) explained the inferiority of the deaf child on memory tasks as a limitation in symbolic behavior. He observed that the hearing children who were studied often verbalized while performing the memory task and concluded that such verbalization enhanced hearing children's performance relative to that of deaf children.

Studies focusing on how the deaf encode visual material into memory have concluded that such individuals make extensive use of a dactylic-kinesthetic code based on sign language and fingerspelling (Locke & Locke, 1971; Wallace & Corballis, 1973). Hoemann, Andrews and DeRosa

(1974) found that the deaf code information relating to the formational parameters of signs in the same way that the hearing make use of phonological cues. Bellugi, Klima and Siple (1974/75) compared deaf and hearing college students and found that, overall, short-term memory mechanisms in the deaf seemed to parallel those found in the hearing. The deaf were shown signs of American Sign Language on a videotape while hearing subjects listened to an audiotape of the same words. The results were consistent with the theory that the signs of American Sign Language are coded by the deaf in terms of their formational parameters.

If sign language can be considered to be a modality comparable to speech, then the manually trained deaf child has access to an articulatory (motor, dactylic or kinesthetic-sensory) modality that might be effective in improving memory. Training the deaf child to sign stimulus items in the same way that hearing children are taught to verbally label may provide equivalent forms of rehearsal. Such training is necessary, as it has been noted that the deaf rarely rehearse spontaneously, and when they do make use of some sort of rehearsal strategy, it is seldom task appropriate. Belmont, Karchmer and Pilkonis (1976) noted that when the deaf adolescents selected their own strategies their memory performance was poor, but when instructed to actively rehearse the stimuli using a cumulative rehearsal technique their performance greatly improved. This specific instructed rehearsal technique also resulted in immediate gains for the hearing group, lending support to the position that sign language is a modality comparable to speech.

Of considerable practical importance is the question of how long-

lasting the effects of rehearsal training are, and also whether rehearsal strategies will generalize from the training task to other similar tasks. According to Stokes and Baer (1977) generalization may be defined as "The occurrence of relevant behavior under different non-training conditions (i.e., across subjects, settings, people, behaviors and/or time) without the scheduling of the same events in those conditions as had been scheduled in the training conditions" (p. 350). In their survey of the current literature these authors emphasized the need to actively program generalization and outlined nine methods designed to accomplish this goal. Included in their review was a technique known as training sufficient exemplars. In this method generalization to new stimuli is accomplished by training the response to a number of exemplars of the class of stimuli rather than training in only one stimulus situation.

In one of the few studies that looked into the maintenance of rehearsal strategies, Keeney, Cannizzo and Flavell (1967) divided children into spontaneous rehearsers and nonrehearsers and investigated generalization of instructed rehearsal by including trials in which the subjects were told that they could repetitively name the items if they wanted to, but that they did not have to. The results indicated that when given the option to rehearse, nonrehearsers tended to abandon the strategy. Similarly, Hagen, Hargrave and Ross (1973) conducted a study with younger (prekindergarten and kindergarten) and older (first and second grade) children that employed a prompted cumulative rehearsal technique. They discovered that, although recall improved when rehearsal was prompted by the experimenter, this improvement was no longer

evident when a delayed test with no prompting was given one week later.

Kellas, Ashcraft and Johnson (1973) gave mildly retarded adolescents a serial recall task, and divided the subjects into an instructed cumulative rehearsal group and a free strategy group. The instructed group showed significantly higher recall scores, and when both groups were retested two weeks later with only free recall instructions, the original cumulative rehearsal group had maintained the strategy, and still showed significantly higher performance. Brown, Campione and Murphy (1974) also reported that active rehearsal improved overall performance of moderately retarded adolescents. Their subjects were divided into instructed rehearsal and control groups and given a serial recall task. The instructed group had significantly higher recall scores than the control group, and when retested on the same task six months later, eight out of ten of the rehearsal subjects had maintained the strategy even in the absence of instructions to do so. The main difference between the studies with normals and those involving retardates seems to be one of age rather than one of rehearsal strategy, since naming or cumulative rehearsal were the instructed techniques in both. The maintenance of induced rehearsal behavior was not achieved by normal children up to seven years of age, but was evident in moderately retarded adolescents with mean mental ages of eight to ten years.

No research has been concerned with the method of training sufficient exemplars in memory tasks. It appears that such programming could be applied in memory tasks by training rehearsal strategies with several examples of the task, and looking for generalization of the re-

hearsal strategy to other similar tasks.

The present experiment was designed to study the effects of instructed rehearsal on retention in manually trained deaf children, and to investigate the generalization of rehearsal behavior to new lists in the absence of instructions to rehearse. Two age groups were used in this study so that developmental differences in accuracy of recall and rehearsal performance could be assessed in deaf children. Rehearsal was experimentally manipulated in a picture probe memory task. Each age group was divided into rehearsal and no rehearsal conditions, with sign language being the rehearsal modality. Children in the rehearsal group were trained to use a repetitive naming strategy which involved signing each pictorial stimulus as it appeared, and at least once during the interitem interval. In the first session, all children were trained on a six picture position probe task, with the rehearsal group being actively instructed to repetitively name the pictures. In the second session, half the children in both the rehearsal and no rehearsal conditions were trained on the original picture list, and half on three new picture lists. A generalization test with a new list of pictures was given immediately following training in the second session, and a delayed generalization test was given ten days later. Rehearsal activity was measured by observing the amount of repetitive naming and amount of naming in the generalization tests.

It was hypothesized that in both age groups: (a) the rehearsal groups would have higher recall scores than the no rehearsal groups on all lists; (b) the repetitive naming behavior would occur on immediate

and delayed generalization tests in the rehearsal but not in the no rehearsal subjects; and (c) those rehearsal subjects who received training on one list would not be as apt to generalize their repetitive naming as compared to rehearsal subjects trained on four lists.

METHOD

Subjects

Subjects were selected from a public school for the deaf which serves the province of Manitoba. Children at this school have hearing threshold levels for speech greater than 90 db, and use manual sign language as a method of communication. There were 16 children in each of two age groups. The mean age of the younger group was 7 years 6 months (range = 6-6 to 8-9, SD = 8.7 months) and the mean age of the older group was 12 years 9 months (range = 12-0 to 13-9, SD = 7.9 months). In the younger group there were 6 girls and 10 boys, whereas, the older group had 5 girls and 11 boys. Teachers' ratings of below average intelligence were used as the basis for excluding 8 younger children (from a pool of 24), and 6 older children (from a pool of 32). This was done prior to sending letters of permission to parents.

Test Materials and Apparatus

The materials used in this experiment were seven sets of picture cards, each containing six items (see Table 6, Appendix A). The picture cards were coloured line drawings of familiar objects traced onto

9.4 cm X 7.5 cm index cards. No two objects having similar hand configurations or from a related category were included in the same list. The cards were placed in seven 10 X 8 cm slots on a 77 X 28 cm wooden stimulus board. Six of the slots were arranged in a row parallel to the base of the board and spaced 2.5 cm apart; the slot for the probe card was centered 5.6 cm above the others. A metronome was used to time the stimulus presentations. All sessions were tape recorded by the experimenter who verbalized subjects' signed and choice responses into the microphone in addition to writing this information on a data sheet.

Procedure

Each child sat at a table in a quiet room, facing the experimenter. All subjects were instructed manually as follows: "You will be shown six picture cards, one at a time. I want you to try and remember the pictures, and where they are on the board. After you have seen each picture it will be turned over on the board. When you have seen all six cards, I will show you another picture which is the same as one you have just seen. I want you to point to the card that is just like it."

Each age group was randomly divided into rehearsal and no rehearsal conditions. Those in the rehearsal condition received instructions prior to the memory task on how to make use of repetitive naming of stimulus pictures as a memory aid. They were told "To help you remember, I want you to sign the name of each picture as I place it on the board, and keep repeating the sign until you see the next picture. I want you to do this for all six pictures." No such instructions were

given to those in the no rehearsal condition. All subjects were given three training trials using the practice list to ensure that they understood the procedure involved in the picture probe position task.

On each trial the appropriate set of cards was shuffled and the cards were placed on the board one at a time from the child's left to right. Each picture was exposed for 4 sec and then turned over; the interitem interval was also 4 sec. The probe card was exposed until the subject pointed to one of the six cards. The experimenter turned over the chosen card, and if it was not correct, showed the subject where the correct card was located. In each block of six trials each position was probed once; the order in which the positions were probed was randomly chosen for each trial block.

The first session consisted of 36 training trials with List 1. Those in the rehearsal condition received instructions to rehearse, and if they forgot to name the item and sign it at least once during the interitem interval the experimenter prompted them by asking for the appropriate sign. Prompting was rarely required after the first three trial blocks. The second session was given on the following day. Half the subjects in the rehearsal and no rehearsal conditions were randomly assigned to the multilist condition and the others to the single list condition. Children in the single list condition received another 18 trials with List 1, whereas children in the multilist condition were given six trials on each of three new lists (Lists 2, 3, and 4). Again, those in the rehearsal group were instructed to rehearse, and prompted if they did not. After a 1 minute break during which the

subjects were allowed to get up and stretch or walk around, the generalization phase of the second session commenced. All subjects received a further 18 trials on a new list (List 5). In this phase of the study children in the rehearsal group were not instructed or prompted to rehearse the stimuli. After a delay of 10 days, the second generalization test took place. All subjects received 36 trials on List 6, again in the absence of any instructions to rehearse.

On each trial the choice response was recorded as correct or incorrect and the position chosen was noted when an error was made. In order to provide a measure of overt rehearsal during the generalization tests with Lists 5 and 6, signing behavior was observed and recorded both in writing and by verbal repetition onto the tape recorder.

After the final testing session all subjects were asked "How did you remember where the pictures were on the board?" and their responses were recorded.

RESULTS

Recall Performance

The recall performance in each phase of the study was analyzed twice. In order to investigate the effects of trial blocks, the number of correct responses in each trial block was calculated for each subject and subjected to a mixed analysis of variance with age, rehearsal condition, and number of training lists as the between-subjects variables, and trial blocks as the within-subjects variable. Each trial block con-

sisted of six trials. In order to examine the effects of serial position, the number of correct responses when each serial position was probed was determined for each subject by summing over trial blocks, and this score was entered into a mixed analysis of variance with age, rehearsal condition, and number of training lists as the between-subjects variables, and serial position as the within-subjects variable. It should be noted that the two analyses of variance produced identical results with respect to the between-subjects factors.

First session performance. Table 7, Appendix B shows the results of the analysis of variance for the number of correct responses per trial block for List 1. This analysis yielded significant main effects for age, $F(1,24) = 4.36$, $p < .05$, and condition, $F(1,24) = 42.49$, $p < .001$. Cell means revealed that the older group performed better than the younger group (4.43 vs. 4.08 mean correct), and that the rehearsal condition was superior to the no rehearsal condition (4.79 vs. 3.72 mean correct).

The summary of the analysis of variance for number of correct responses per serial position for List 1 is contained in Table 8, Appendix B. A significant main effect for serial position was noted, $F(5,120) = 30.51$, $p < .001$. Figure 1 shows the typical serial position curve with primacy and recency effects. There were no significant interactions between serial position and the other variables.

Second session performance: Training phase. During this portion of the second session, subjects in the single list condition received a fur-

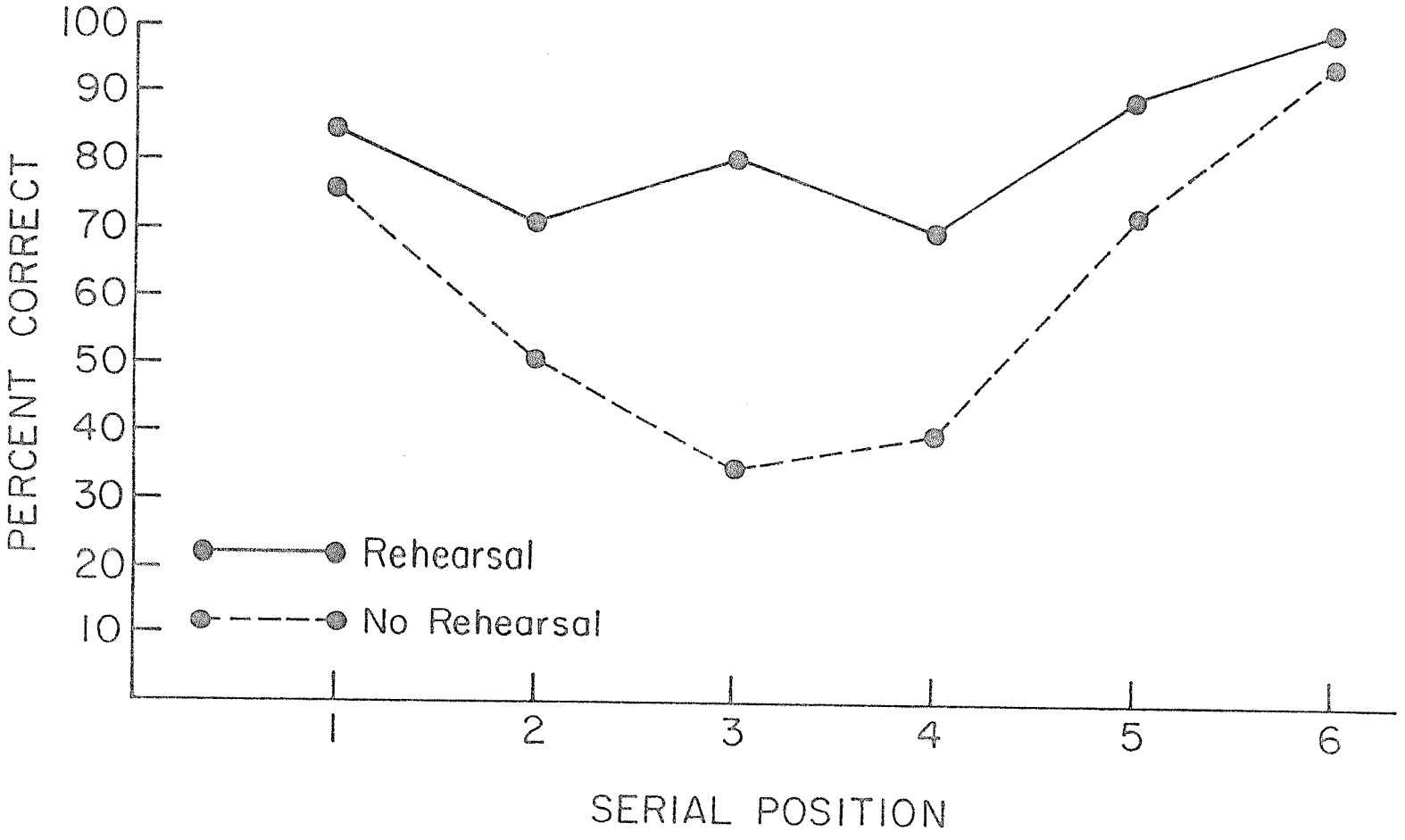

Figure 1. Percentage of correct responses at each serial position on List 1 for rehearsal and no rehearsal subjects.

ther three trial blocks on List 1, whereas subjects in the multilist condition received one trial block on each of three new lists (Lists 2, 3, and 4). The analysis of variance for the number of correct responses per trial block for these subjects is contained in Table 9, Appendix B. Trial blocks and lists are confounded for the multilist group in this analysis. Significant main effects were obtained for rehearsal condition, $F(1,24) = 15.66$, $p < .001$, and number of training lists, $F(1,24) = 4.30$, $p < .05$. The three-way interaction involving number of training lists, rehearsal condition, and trial blocks was also significant, $F(2,48) = 5.39$, $p < .01$.

The cell means for the triple interaction are presented in Figure 2. Post-hoc pairwise comparisons were performed on the means involved in this interaction using the Tukey HSD statistic (Kirk, 1968). The rehearsal condition was significantly superior to the no rehearsal condition at trial blocks one and three for the single list condition and trial blocks two and three in the multilist condition. There was no difference between rehearsal and no rehearsal groups on trial block two in the single list condition and on trial block one in the multilist condition, $HSD(4,30) = 1.07$, $\alpha = .05$.

On trial block one the no rehearsal group in the multilist condition had significantly higher recall scores than the no rehearsal group in the single list condition, $HSD(4,30) = 1.07$, $\alpha = .05$. Other comparisons between single and multilist conditions with trial block and rehearsal group equated were nonsignificant.

In the single list condition there were no significant differences

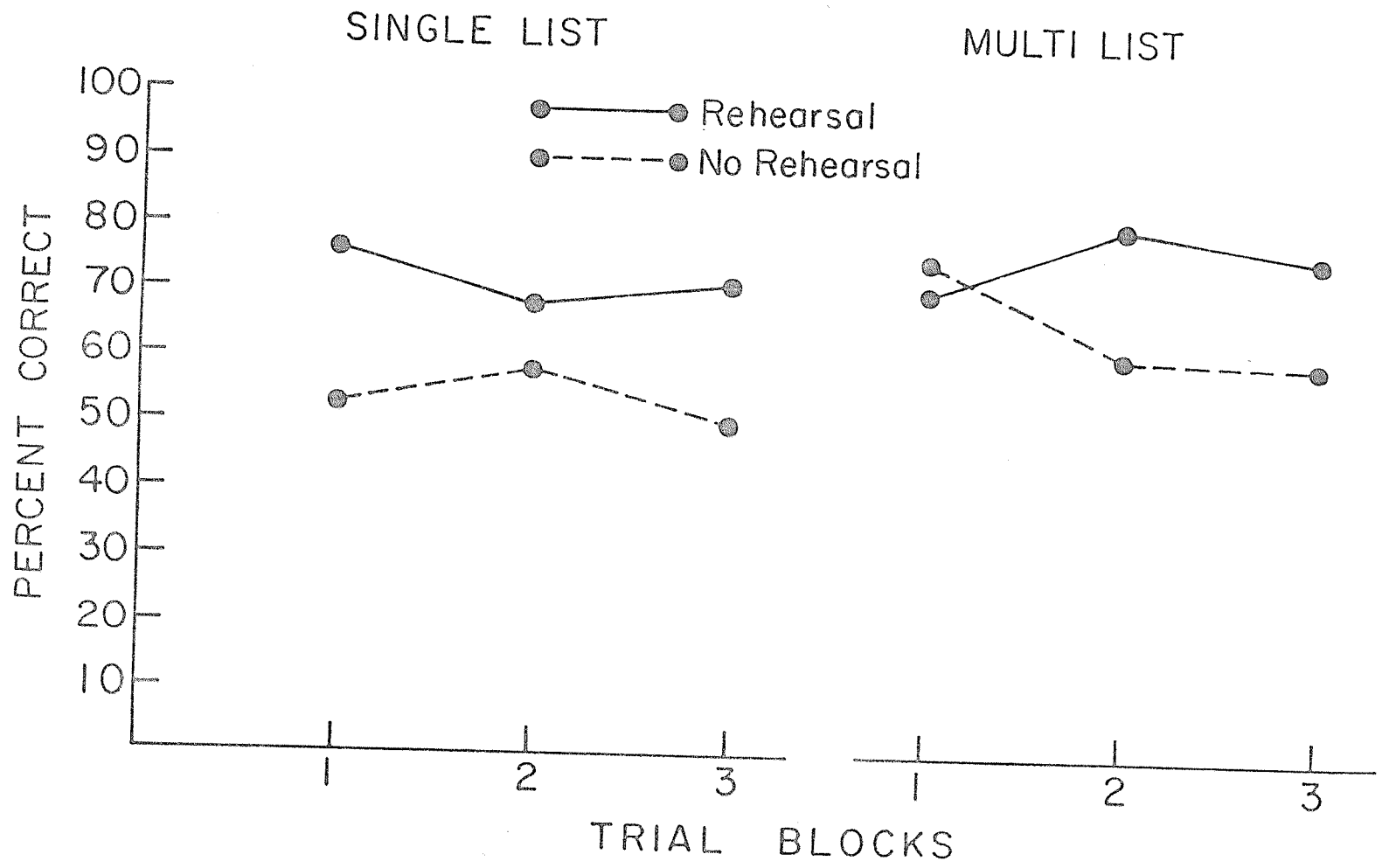

Figure 2. Percentage of correct responses on each trial block during the training phase of session 2 for single and multilist conditions.

across trial blocks for either the rehearsal or no rehearsal groups. In the multilist condition recall performance on trial block one was significantly greater than on trial block three for the no rehearsal group, HSD(4,30) = .87, α = .05; but no significant differences were noted across trial blocks for the rehearsal group.

The summary of the analysis of variance for the number of correct responses per serial position for the training phase of session two is contained in Table 10, Appendix B. The analysis yielded a significant main effect for serial position, $F(5,120) = 18.07$, $p < .001$. As can be seen in Figure 3, primacy and recency effects were obtained.

Second session performance: Generalization test phase. This part of the second session constituted the first generalization test. The summary of the analysis of variance for number of correct responses over the three blocks of trials on List 5 is contained in Table 11, Appendix B. This analysis revealed that the rehearsal condition (mean correct = 4.69) was superior to the no rehearsal condition (mean correct = 3.81), $F(1,24) = 17.76$, $p < .001$. In addition there was a significant main effect for age, $F(1,24) = 4.87$, $p < .05$; and a significant two-way interaction between trial blocks and age, $F(2,48) = 8.26$, $p < .001$. This interaction is presented in Figure 4. Post hoc comparisons of older and younger groups indicated that the older group was superior to the younger group on trial blocks one and three, but the groups did not differ on trial block two, HSD(2,30) = .58, α = .05. The older group's performance decreased between trial blocks one and two and increased between trial blocks two and three; no significant changes over trial blocks were noted for the

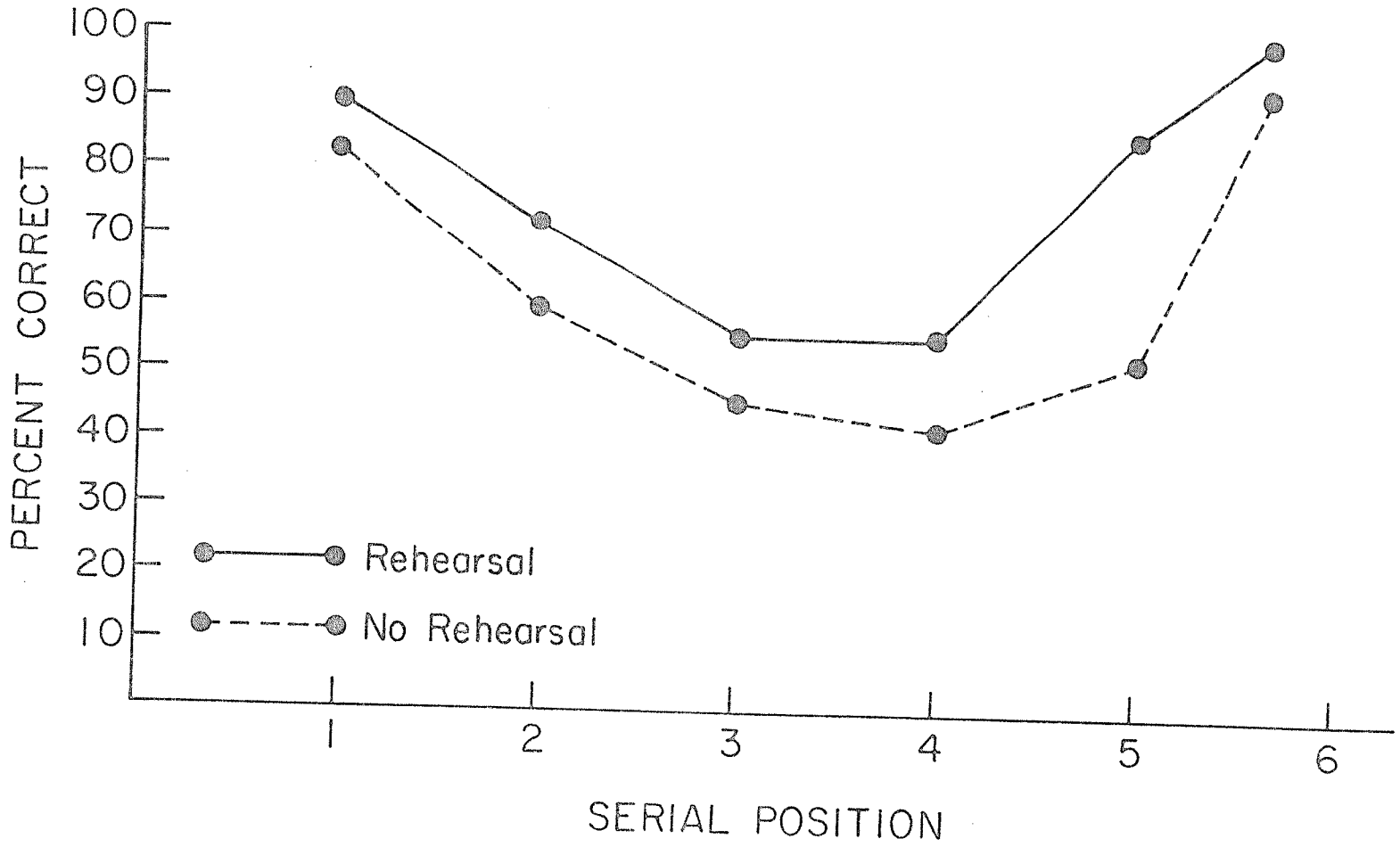

Figure 3. Percentage of correct responses at each serial position during the training phase of session 2 for rehearsal and no rehearsal subjects.

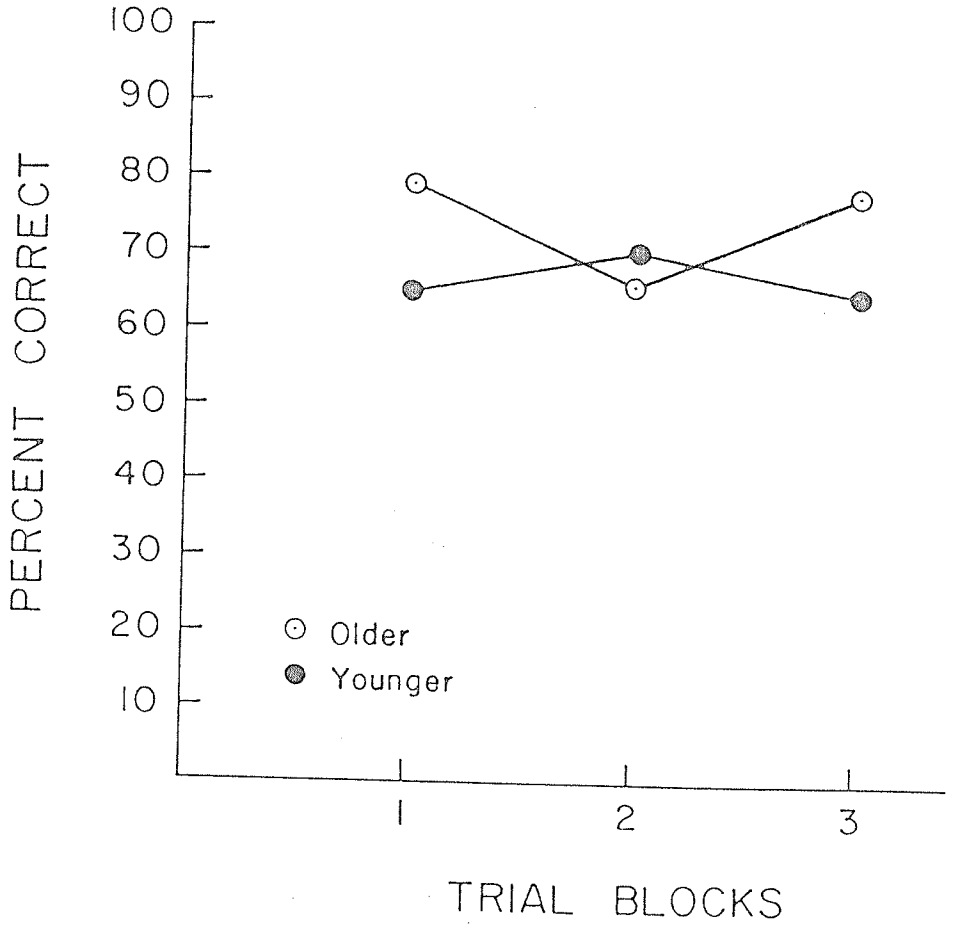

Figure 4. Percentage of correct responses on each trial block during the generalization test phase of session 2.

younger group, HSD(2,30) = .44, α = .05.

The summary of the analysis involving number of correct responses per serial position for List 5 is contained in Table 12, Appendix B, and again a significant main effect for serial position was obtained, $F(5,120) = 17.17$, $p < .001$. Figure 5 shows similar primacy and recency effects to those found in previous serial position analyses.

Third session performance. The analysis of variance involving the number of correct responses per trial block for List 6 (Table 13, Appendix B) indicated that those in the rehearsal condition (mean correct = 4.72) performed significantly better than those in the no rehearsal condition (mean correct = 3.73); $F(1,24) = 29.08$, $p < .001$. Table 14, Appendix B contains the summary of the analysis of variance for number of correct responses per serial position, and as in the previous session a significant main effect for serial position was noted, $F(5,120) = 48.28$, $p < .001$. A significant two-way interaction between serial position and rehearsal condition was also revealed, $F(5,120) = 7.34$, $p < .001$. The means involved in this interaction are shown in Figure 6. Tukey HSD comparisons revealed significant differences between rehearsal conditions on serial positions two to four, but not one, five, and six, HSD(2,30) = .71, α = .05.

Rehearsal Activity

Repetitive Naming. Repetitive naming scores were obtained for each subject by counting the number of pictures in each block of trials that

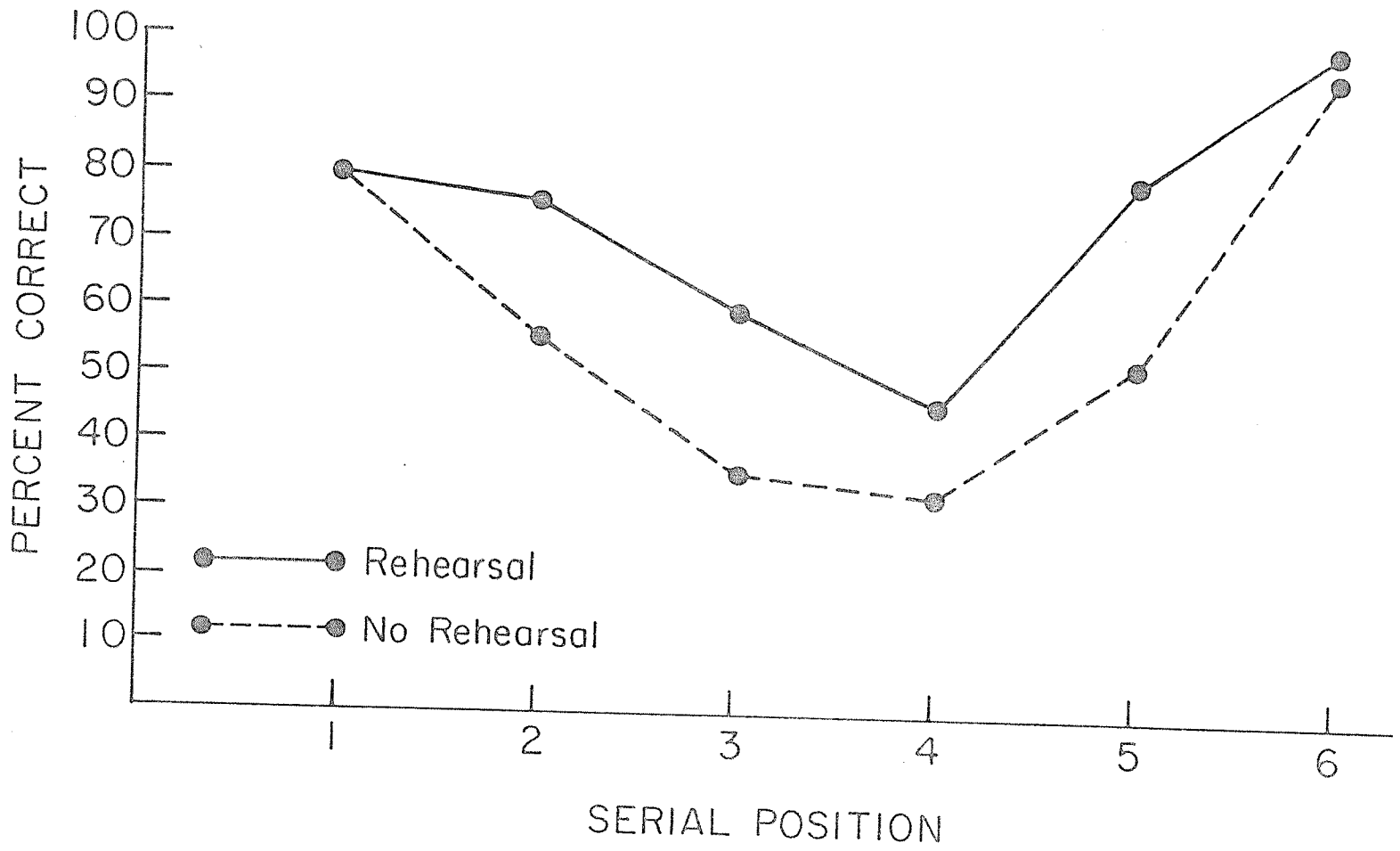

Figure 5. Percentage of correct responses at each serial position during the generalization test phase of session 2 for rehearsal and no rehearsal subjects.

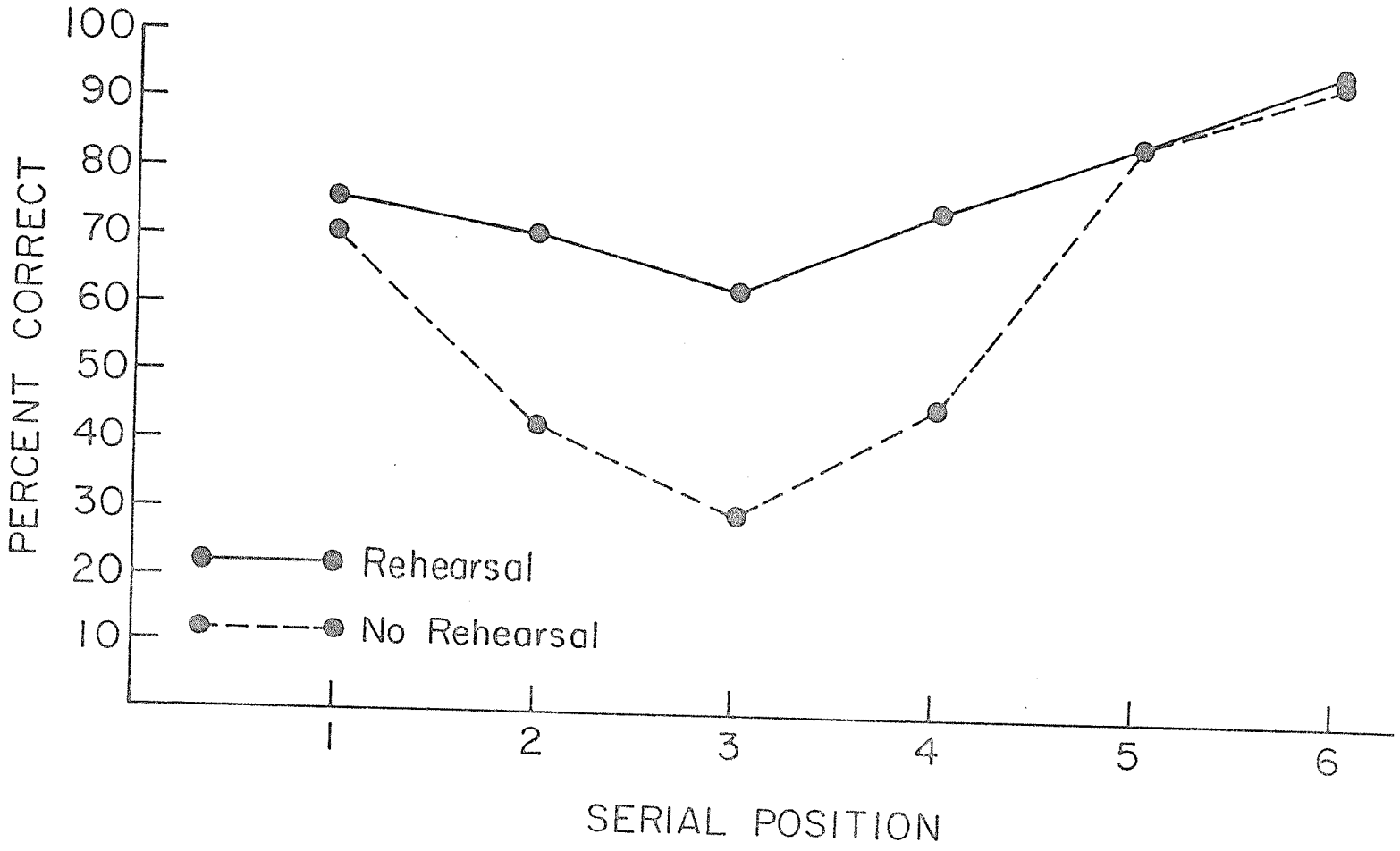

Figure 6. Percentage of correct responses at each serial position on List 6 for rehearsal and no rehearsal subjects.

were signed by the subject, both when the picture was presented and at least once during the interitem interval. Since six pictures were presented on each trial, repetitive naming scores could range from 0 to 36. None of the subjects in the no rehearsal condition showed repetitive naming activity; whereas 10 of the 16 subjects in the rehearsal condition made repetitive naming responses in both the immediate and delayed generalization tests.

The raw scores for the repetitive naming activity of the subjects in the rehearsal condition on the immediate generalization test are contained in Table 1. Perfect repetitive naming scores were obtained for six of the younger subjects and four of the older subjects. The remaining subjects showed no repetitive naming. A χ^2 test was carried out to compare the proportion of subjects who rehearsed in the two age groups: the difference was nonsignificant, $\chi^2(1) = .27$, $p > .05$. With respect to number of training lists, five subjects in both the single and the multilist conditions repetitively named the items. No changes in repetitive naming occurred over trial blocks.

The repetitive naming scores for rehearsal condition subjects on the delayed generalization test are contained in Table 2. Perfect repetitive naming scores were obtained for two of the younger subjects and three of the older subjects. Four of the younger subjects and one older subject repetitively named some of the items, and the six remaining subjects showed no repetitive naming. In the single list condition, two subjects repetitively named all the items, three subjects repetitively named some of the items, and three showed no repetitive naming. In the

Table 1

Repetitive Naming by Subjects in the Rehearsal Condition on the Immediate Generalization Test

Age Group	Number of Training Lists	Subjects	Trial Blocks		
			1	2	3
Younger	Single	1	36	36	36
	Single	2	0	0	0
	Single	3	36	36	36
	Single	4	36	36	36
	Multi	5	36	36	36
	Multi	6	0	0	0
	Multi	7	36	36	36
	Multi	8	36	36	36
Older	Single	17	0	0	0
	Single	18	0	0	0
	Multi	19	36	36	36
	Multi	20	36	36	36
	Multi	21	0	0	0
	Single	22	36	36	36
	Single	23	36	36	36
	Multi	24	0	0	0

Table 2

Repetitive Naming by Subjects in the Rehearsal Condition on the Delayed Generalization Test

Age Group	Number of Training Lists	Subjects	Trial Blocks					
			1	2	3	4	5	6
Younger	Single	1	18	0	0	0	0	0
	Single	2	0	0	0	0	0	0
	Single	3	36	36	36	18	30	28
	Single	4	34	36	36	36	32	36
	Multi	5	36	36	36	36	36	36
	Multi	6	0	0	0	0	0	0
	Multi	7	36	36	12	0	0	0
	Multi	8	36	36	36	36	36	36
Older	Single	17	0	0	0	0	0	0
	Single	18	0	0	0	0	0	0
	Multi	19	36	36	36	36	12	0
	Multi	20	36	36	36	36	36	36
	Multi	21	0	0	0	0	0	0
	Single	22	36	36	36	36	36	36
	Single	23	36	36	36	36	36	36
	Multi	24	0	0	0	0	0	0

multilist condition, three subjects repetitively named all the items, two repetitively named some of the items, and three showed no repetitive naming. χ^2 tests comparing the proportion of subjects who rehearsed in the two age groups and in the two training conditions revealed nonsignificant differences for both age groups, $\chi^2(1) = .27$, $p > .05$, and number of training lists, $\chi^2(1) = .57$, $p > .05$. The effect of trial blocks on the proportion of subjects who rehearsed was investigated by performing the Cochran Q test for related samples (Siegel, 1956) but no significant effect was found, $Q(5) = 8.68$, $p > .05$.

Naming. In the rehearsal condition, two younger subjects and two older subjects engaged in naming activity but not repetitive naming during the immediate generalization test (see Table 3). That is to say they signed the presented picture, but did not repeat the sign during the interitem interval. In the delayed generalization test, one of these younger subjects and one of these older subjects continued to engage in naming (see Table 4). One older subject who had not named during the first generalization test named several pictures at the beginning of the second generalization test. In addition, naming occurred in one of the younger no rehearsal subjects and two of the older no rehearsal subjects in the immediate generalization test, and in both of these older jects in the delayed generalization test.

Post-test Question

Responses to the post-test inquiry on how the children had remember-

Table 3

Naming Scores for Subjects who Named Items

in the Immediate Generalization Test

Age and Condition	Number of Training Lists	Subjects	Trial Blocks		
			1	2	3
Younger Rehearsal	Single	2	36	36	36
	Multi	6	36	36	36
Older Rehearsal	Single	17	36	36	36
	Single	18	36	36	36
Younger No Rehearsal	Multi	14	5	3	0
Older No Rehearsal	Single	27	6	12	12
	Multi	30	12	0	0

Table 4

Naming Scores for Subjects who Named Items

in the Delayed Generalization Test

Age and Condition	Number of Training Lists	Subjects	Trial Blocks					
			1	2	3	4	5	6
Younger	Single	2	36	36	36	36	36	36
Rehearsal	Multi	6	24	0	0	0	0	0
Older	Single	18	36	36	36	36	36	36
Rehearsal	Multi	24	24	12	12	0	0	0
Older	Single	27	6	0	0	0	0	0
No Rehearsal	Multi	30	6	0	0	0	0	0

ed the pictures were independently categorized by two different raters and agreement was obtained for the responses of 31 of the 32 subjects, yielding an inter-rater reliability of 96.87%. The categories were: A = "I did what you told me"; B = "I signed the pictures"; C = "I remembered"; D = No reply. The frequency of each type of response can be seen in Table 5.

Of the two younger rehearsal subjects who gave a category A response (I did what you told me), one repetitively named and the other named the items. All of the five subjects in category B (I signed the pictures) repetitively named the items. The eighth younger rehearsal subject gave a category C response (I remembered) and did not repetitively name, but did name some of the items. Six of the older rehearsal subjects gave category B responses (I signed the pictures) and four of them repetitively named the items, while two named the items in the immediate generalization test. In the delayed generalization test one of these two naming subjects continued to name, while the other discontinued naming. The remaining two older rehearsal subjects gave category C answers (I remembered), and one of these subjects did name some of the items in the delayed generalization test. In summary,thirteen of the fifteen rehearsal subjects who engaged in some form of rehearsal behavior gave category A or B answers.

Three of the younger no rehearsal subjects gave category C responses (I remembered) and four failed to answer the question. None of these subjects engaged in any overt rehearsal behavior. The remaining younger no rehearsal subject who gave a category B answer (I signed the pictures) did name the pictures during the first generalization test. In the older no

Table 5

Post Test Inquiry Responses

Age	Condition	Response Category			
		A	B	C	D
Younger	Rehearsal	2	5	1	0
Younger	No Rehearsal	0	1	3	4
Older	Rehearsal	0	6	2	0
Older	No Rehearsal	0	2	5	1

rehearsal group, the two subjects who said they signed the pictures did engage in some naming activity during both generalization tests. Of the five subjects who gave category C answers, and the remaining subject who failed to answer the question, none engaged in either repetitive naming or naming behavior. In summary, all three of the no rehearsal subjects who engaged in some naming gave category B answers.

DISCUSSION

The present study examined the effects of a repetitive naming rehearsal strategy on the memory performance of manually trained deaf children. During the first session, in which rehearsal subjects were instructed and prompted to repetitively name the stimuli, a significant main effect for rehearsal condition was noted, indicating that the rehearsal subjects in both age groups performed at a higher level than no rehearsal subjects.

In the training phase of session 2, an interaction was found between trial blocks, number of training lists, and rehearsal condition. Rehearsal subjects in the single list condition were superior to no rehearsal subjects on trial blocks one and three, but not on trial block two. Rehearsal subjects in the multilist condition were significantly superior to no rehearsal subjects on trial blocks two and three, but not on trial block one. On trial block one, the no rehearsal subjects in the multilist condition were also significantly superior to the no rehearsal subjects in the single list condition. Thus, receiving a new

training list (List 2) at the beginning of the second session led to an increase in memory performance for the no rehearsal subjects. The multilist rehearsal subjects did not show this effect, however, and the performance of the multilist no rehearsal subjects declined on trial blocks two and three (Lists 3 and 4). These results for the no rehearsal subjects may have been due to a temporary increase in attention to the task elicited by the new list at the start of session 2. By List 3, the introduction of new pictures may have lost its novelty. Rehearsal subjects would not be expected to show a similar improvement in performance as their repetitive naming of the items already maximized attention to the stimuli.

These results demonstrate that a repetitive naming rehearsal strategy can be used by deaf children as young as seven years of age as a means of improving recall performance. Belmont et al. (1976) found that sign language rehearsal was an effective strategy for deaf adolescents to employ to improve recall, a result confirmed in the present experiment with much younger subjects. Verbal repetitive naming has also been found to increase memory performance of first grade hearing children (Keeney, Cannizzo & Flavell, 1967). It would appear that the use of American Sign Language by deaf children is comparable to the use of speech by normal hearing children as a rehearsal modality in memory tasks.

The superior recall performance of rehearsal trained subjects carried over into both the immediate and delayed generalization tests, despite the fact that no instructions to rehearse were given. This per-

sistence of superior recall performance in young deaf children 10 days after rehearsal training is consistent with the findings of Kellas, Ashcraft and Johnson (1973) who found that when moderately retarded adolescents were trained to rehearse they maintained their superior recall scores after a two week lapse in testing. Keeney, Cannizzo and Flavell (1967) found no evidence of rehearsal maintenance in their young hearing subjects who were classified as non-rehearsers, but it appears that deaf and retarded individuals who do not normally spontaneously rehearse can, when instructed, produce and maintain such behavior.

Analysis of recall data failed to reveal an interaction between serial position and rehearsal condition on training lists and on the immediate generalization list, although the expected primacy and recency effects were obtained. This indicates that the repetitive naming strategy facilitated recall of the items equally at each serial position. Past studies concerned with serial position effects have shown that cumulative rehearsal enhances primacy and recency performance, while simple naming enhances recall of only the last items in the list (Kingsley & Hagen, 1969). The present study has demonstrated that repetitive naming, like cumulative rehearsal, can enhance recall at all serial positions. This finding supports the position that this type of rehearsal aids both short-term storage of the last items and long-term memory for first and middle items. In delayed generalization test performance (List 6) the rehearsal group was superior to the no rehearsal group only on the middle items, indicating that repetitive naming improved only the long-term storage of these items.

Differences in recall attributable to age were present in session one and in the first generalization test phase. In the latter case, older subjects were superior to younger subjects on trial blocks one and three. The fact that the older deaf subjects were not consistently superior to the younger deaf subjects on all lists suggests that older deaf children do not develop memory processing strategies in the same way as older hearing children. This is supported by the finding that no age differences were noted in repetitive naming during either generalization test. Older hearing children are much more apt to spontaneously rehearse than younger hearing children (Flavell, Beach & Chinsky, 1966), and usually produce significantly higher recall scores.

One explanation for the age differences noted in the initial training and immediate generalization sessions is that novel situations may be more distracting for younger deaf children. List 1 began the training sessions of the experiment and the younger children may have needed more time to familiarize themselves with the procedure. By the second session, their performance equaled that of the older children but, when the first generalization test began, their recall scores again dropped below the older group. This latter decline in performance could have been caused by the novel situation created when no rehearsal instructions or prompting to rehearse were given during the first generalization test session. It would appear that the developmental differences in recall characteristically found in normal children may not be as common in the deaf, and may only become apparent in novel task situations.

The second hypothesis, that repetitive naming behavior would occur

in rehearsal but not in no rehearsal subjects during the generalization tests was supported by the fact that ten of the sixteen rehearsal subjects showed repetitive naming behavior as compared with none of the no rehearsal subjects. Two of the younger and three older rehearsal subjects failed to repetitively name during the generalization tests, but did engage in some simple naming behavior. It would seem, therefore, that transfer of some type of rehearsal activity was accomplished by all of the younger rehearsal subjects and by seven of the eight older rehearsal subjects. Brown, Campione and Murphy (1974) have shown that mildly retarded adolescents maintained a rehearsal strategy six months after training. The present study provides evidence that young deaf children also generalize rehearsal behavior, over time, and to new test stimuli.

In the no rehearsal groups, seven of the eight younger subjects and six of the eight older subjects failed to engage in any spontaneous sign language rehearsal, and the three that did rehearse only named the test items. This agrees with Belmont et al. (1976) who noted that spontaneous rehearsal in deaf adolescents was rare. In contrast, normal hearing children usually spontaneously rehearse by the second grade (Flavell, Beach & Chinsky, 1966). The deaf children in the present study did not spontaneously produce rehearsal behavior but were easily trained to use repetitive naming. This would seem to indicate that although they are production deficient they can be taught to successfully employ and maintain sign language rehearsal.

The prediction that those subjects who received four training lists

would be more apt to generalize the rehearsal strategy than those trained on a single list was not supported. Subjects in these two conditions did not differ significantly in amount of rehearsal behavior or recall scores during the generalization sessions.

The responses to the question concerning how the subjects remembered the pictures gives evidence of how aware these deaf children were of themselves as memorizers. Their responses indicate that eleven of the rehearsers were able to report that they had signed the stimuli, two of the other five rehearsers said they had done what they were instructed to do, and the three remaining subjects were unable to express clearly how they had remembered. Among the nonrehearsers, the three who said they had signed the stimuli had indeed done so, but ten others were unable to describe any rehearsal technique and five did not reply to the question. It is clear from this data that, unless instructed, deaf subjects have little knowledge of various rehearsal strategies.

It is evident that sign language rehearsal training not only increases memory performance in manually trained deaf children, but that such behavior can become generalized over time, and to other test items. As the deaf appear to be developmentally slow in acquiring memory processing skills, such training should be provided early in deaf children's education in order to maximize memory performance and give them the opportunity to compete on an equal basis with hearing children. The present study demonstrates that deaf children as young as seven years can successfully employ a repetitive naming strategy.

LITERATURE REVIEW

Development of Rehearsal Strategies

Researchers have long been interested in investigating methods designed to increase both short and long-term memory. One of the most common techniques employed in memory tasks is verbal rehearsal, both overt and covert. There are three simple forms of verbal rehearsal (Allik & Siegel, 1976): naming, which involves producing a verbal label for a stimulus item; repetitive naming - repeating the name of an item during the interitem interval; and cumulative rehearsal, when several items are repeated together in an additive pattern. Research into the development of rehearsal strategies has addressed itself to a number of questions. First and foremost, does rehearsal facilitate recall? Secondly, at what age does spontaneous rehearsal occur? Thirdly, how permanent are the effects of instructed rehearsal techniques?

With reference to the first question, Kurtz and Hovland (1953) designed an experiment to study the effects of naming the items in a list on subsequent memory for the items. A further aspect of this study was that they tested whether a recognition task in verbal form (words), as compared to one in visual form (pictures), would be more sensitive to the effects of verbalization. Subjects were fifth to seventh grade children who were divided into verbalization and control groups, and given either a list of words or a sheet of photographs corresponding to an actual array of objects. Age was not a variable in this experi-

ment. The verbalization group circled the name of the corresponding object and named it aloud. The control group circled the corresponding picture without naming. One week later, half the subjects in each group were given booklets containing the original stimulus items, plus an equal number of novel pictures (visual) or names of pictures (verbal) and were instructed to circle those items that they remembered from the original list. This constituted the recognition task. The other half were instructed to write down as many of the original items as they could remember - the recall task.

Results indicated that significant differences occurred between the verbal and visual forms of the recognition task, with the visual being superior; and between the verbalization group and the control, with the verbalization group exhibiting higher recognition scores. In addition, the verbalization group also exhibited superior performance on the recall task. In this study, the hypothesis that accuracy of retention would be increased by naming at the time of stimulus observation was supported.

Flavell, Beach and Chinsky (1966) studied children from kindergarten, grade two, and grade five in an attempt to test the production deficiency hypothesis, which states that there is a stage during which young children tend not to verbally mediate overt behavior, even though they understand and can use the correct words. In this study, the experimenter pointed to a list of pictures and the children were asked to remember the order in which the experimenter had pointed to the pictures and then point back in the same sequence. An experimenter trained in lip-reading observed the children's mouths in order to detect any overt

rehearsal. All children were asked to tell the experimenter at the end of the test session how they had remembered the pictures. It was hypothesized, on the basis of the production deficiency hypothesis, that second graders would produce more verbal rehearsal (naming) than children in kindergarten. Fifth graders were included in the study to test a second hypothesis that rehearsal might be internalized in older subjects, thus making it less noticable to direct observation.

The results indicated that second graders produced significantly more verbalizations than kindergarten children. Surprisingly, this increase in spontaneous rehearsal carried over into the older group of fifth grade subjects, who verbalized even more than the second grade children, thus negating the internalization hypothesis. It may be that the kindergarten children had a production deficiency, and hence were too young to engage in the kinds of intellectual activities which are involved in verbal coding and rehearsal.

This particular study made no attempt to test the question of whether the developmental increase in spontaneous verbalization actually improved recall, but Keeney, Cannizzo and Flavell (1967) addressed this aspect of performance in a study with first grade children. The experimental design was essentially the same as that used in the previously mentioned study, with the exception that at the end of the first session children were divided into rehearsers and nonrehearsers. This was done on the basis of direct observation of spontaneous verbalization (naming) and according to subjects' responses to an inquiry on how they had remembered the stimuli. In the second session, rehearsers were further

divided into controls who repeated the procedure of session one, and experimental subjects who received induced rehearsal instructions involving repetitive naming of the items. The nonrehearsers were all assigned to the experimental condition. At the end of the second session all experimental subjects were given three trials in which the experimenter told them that they could say the name of the items if they wanted to, but that they did not have to.

Results revealed that: (a) the serial recall of the spontaneous rehearsers was superior to that of the nonrehearsers; (b) when nonrehearsers were taught to rehearse, their performance rose to the level of the rehearsers; and (c) when given the option to rehearse, nonrehearsers tended to abandon the strategy. This third finding appears to support the hypothesis that rehearsal deficiency is a failure of utilization of rehearsal strategies rather than a production deficiency. Since some of the children in this study were classified as rehearsers, it would seem that rehearsal strategies may develop in children as young as six or seven years old, but that some children of this age may not be ready to make use of such techniques.

Developmental changes in memorization processes were also investigated by Flavell, Friedrichs, and Hoyt (1970) in a study designed to assess children's ability to predict their own immediate memory span, and also their ability to decide when they had studied a list of items long enough to achieve perfect recall. In the first phase of the study, younger (nursery school and kindergarten) and older (second, and fourth grade) children were given the task of estimating their immediate memory

span for lists of familiar pictures, up to a maximum of ten pictures. The experimenter then assessed their actual span for such items by having subjects recall lists of increasing length. Three test trials were then given, with the length of the picture list determined for each subject according to his actual object span. Subjects sat facing a stimulus panel which contained ten viewing windows. When subjects pressed the buttons directly under each window, a picture was exposed, and remained visible for as long as the button was depressed. When each subject felt that he had memorized the list of pictures in the correct order, he rang a bell and repeated the list aloud. The experimenter was absent from the room when the preschoolers, fourth graders and half the kindergarten and grade two children studied the lists, and remained in the room when the rest of the kindergarteners and second graders studied. Another experimenter trained in lipreading was seated behind a one way mirror, and observed each testing session. Her purpose was to classify the children's behavior into four types of study patterns: naming, where the child named the picture as it was exposed; anticipation, where the child named the picture before it was exposed; rehearsal, where the child engaged in repetitive naming or cumulative rehearsal; and gesture, pointing to the buttons or head nodding.

At all grade levels predicted memory span was greater than actual span, with the accuracy of prediction significantly greater for the older children. Actual span also increased with age across the four grade levels. The older children were also better able to assess when they had memorized the lists well enough to recall them perfectly. With

respect to study period behavior, the younger children were much more apt to simply name the stimuli, while the older children made far more use of anticipation, rehearsal and gestures, as well as combinations of these behaviors. Naming by the younger children was not always associated with higher recall scores, but those younger children that did make use of anticipation and/or rehearsal did exhibit more accurate recall. The presence or absence of the experimenter had no effect upon the study behavior or recall scores of any of the subjects.

It would appear that nursery school children do not produce overt verbalizations as an aid in memory tasks. Locke and Fehr (1970) studied four and five year olds in an attempt to discover whether children this young would spontaneously verbalize in memory tasks. The stimuli used in this experiment were 15 pictures whose labels, when spoken, contained at least one labial phoneme (/p/, /b/, /m/, /f/, /v/) and 15 whose labels did not. Each trial consisted of three slides presented one at a time at 4 sec intervals, followed by a 12 sec delay. The subjects were instructed to wait for a red light to appear before recalling the slides. This delay was referred to as the rehearsal period, although subjects were not given any instructions to rehearse. Electrodes were placed on the subjects' lower lip and chin, and oral activity was monitered by electromyography (EMG). In addition, a small microphone was attached to the subjects' clothing just below the chin. All audible activity was recorded at a high level by a tape recorder.

Means based on the maximum peaks from each subject's EMG tracings were analyzed to determine if oral activity was actually speech, and when

in the experiment this activity occurred. Audible articulatory activity was infrequent, but labial-nonlabial differences indicated that these children did covertly name the pictures during their presentation but not during the period provided for rehearsal. This study lends support to the position that young children spontaneously produce verbal names for familiar stimuli, but that they do not make use of this naming behavior in the absence of the stimuli, to aid recall.

Kingsley and Hagen (1969) tested the hypothesis that, in a serial-order short-term memory task, cumulative rehearsal of the labels would facilitate recall on early serial items, and that overt naming would facilitate recall on the last serial item. Nursery school children were used as subjects, because they would not be likely to spontaneously rehearse or label the stimuli. Overt versus covert naming, and spontaneous versus induced rehearsal were the two variables manipulated. The children were divided into four experimental groups: (a) covert labels, spontaneous rehearsal - in which the subjects were given labels for the stimuli and instructed to say them subvocally; (b) overt labels, spontaneous rehearsal - in which the subjects were given labels and instructed to use them overtly; (c) overt labels, induced rehearsal - in which subjects were given labels, told to pronounce them aloud, and also cumulatively rehearse, in the correct order, all of the cards previously presented to them for that trial; and (d) a no label control group. It was predicted that the overt labels, induced rehearsal group would perform better than the overt labels, spontaneous rehearsal group, who in turn would perform better than the covert labels, spontaneous rehearsal

group. All three groups were expected to be superior to the control. Six nonsense figures were used as the test stimuli. Five cards were exposed one at a time and then turned face down. A probe card identical to one of the five was then shown, and the subjects were required to turn over the correct test card.

The results indicated that primacy and recency effects did vary as a function of experimental treatments, in that: (a) recency performance was facilitated by overt naming; (b) performance on intermediate and early serial positions was facilitated by cumulative rehearsal; (c) simple possession of labels was not sufficient to increase primacy recall in the absence of naming or rehearsal, since those in the spontaneous rehearsal group did no better on primacy than those in the control group; and (d) spontaneous use of a rehearsal strategy was not widespread among nursery school and kindergarten children. This study supported the view that cumulative rehearsal and simple naming increase the accuracy of recall.

Hagen, Hargrave and Ross (1973) tested younger (prekindergarten and kindergarten) and older (first and second grade) children on a picture position probe task that investigated the effect of prompted rehearsal on memory retention. All children were randomly assigned to either a rehearsal-prompt or a rehearsal-no prompt condition, and the stimuli were presented in the same manner as in the Kingsley and Hagen (1969) study. Each subject received three blocks of trials. The first block served as a control condition and no rehearsal instructions were given. In the second block, all children received cumulative rehearsal instruc-

tions, but half the subjects were prompted if they forgot to name the stimuli or named them out of order, and the other half were not. A week later the third block of trials, which replicated the control block, was given.

When performance on trial block one and trial block two were compared, results indicated that the older group performed significantly better than the younger group. Recall by the younger subjects in the rehearsal-prompt condition improved on the second trial block, but no improvement was found for the subjects in the other condition. Recall scores for the third trial block revealed no improvement resulting from the rehearsal training on trial block two. These authors concluded that the younger children were not capable of using rehearsal unless prompting was provided, and hence failed to show improved performance on trial block three. Since the older subjects spontaneously used rehearsal strategies, their performance was superior to the younger children and less influenced by the rehearsal instructions.

Naus, Ornstein and Aivano (1977) believed that developmental differences in rehearsal content, rather than rehearsal frequency, affect recall performance, and they designed a study that investigated the effects of processing time and rehearsal training upon recall. Presentation rate (processing time) and rehearsal instructions were the variables manipulated. Third and sixth grade children were divided into fast (5 sec per item) and slow (10 sec per item) presentation groups, and these groups were further assigned to spontaneous covert control, spontaneous overt, and instructed overt rehearsal conditions. The spontaneous overt

control group was similar to standard free recall, the spontaneous overt rehearsal subjects were instructed to rehearse aloud as they normally would to themselves, and the instructed overt rehearsal subjects were told to rehearse aloud the presented word with any other two words from the list - cumulative rehearsal. Stimuli were 18 unrelated words, presented in four trials.

Rehearsal data from the two spontaneous groups indicated that third grade girls made use of longer processing time to increase rehearsal activity, which in turn served to increase their recall. Third grade boys and sixth grade girls and boys did not show this effect. Neither third grade nor sixth grade children in the instructed rehearsal condition had higher recall scores than subjects in the spontaneous rehearsal conditions. The sixth grade children did exhibit superior recall scores over third grade children, with the exception of the third grade girls at the 10 sec presentation rate. Support for the direct relationship between rehearsal content and recall was supplied only by the third grade girls in the 10 sec condition.

Further research into the question of developmental differences in rehearsal activity was conducted by Weist and Crawford (1977). These authors carried out a study with children from grades one, three, and five for the purpose of evaluating the development of organization strategies in rehearsal processes. The children were randomly assigned to one of four experimental groups: (a) free rehearsal, free recall, in which the children were permitted to rehearse and recall the words in any order; (b) free rehearsal, cued recall, where they could rehearse the

words in any order but had to recall them in categories; (c) cued rehearsal, free recall, where they were required to rehearse the words in categories but could recall them in any order; and (d) cued rehearsal, cued recall, where they were required to both rehearse and recall the words in categories. Test items were a list of 24 pictures, arranged into six categories and exposed in random order.

Results from this study revealed that organized rehearsal and the amount of recall both covaried with age. At all levels, performance improved when the children were taught to categorize during rehearsal, and even the youngest children were able to make use of organized rehearsal when it was cued. Item-by-item analysis of first grade data produced significant correlations between the number of repetitions and the probability of recall; significant correlations were not found for the older subjects. It seems, that at least for the younger children, the quantity of rehearsal was linked to retention.

Allik and Siegel (1976) investigated the use of the cumulative rehearsal technique with nursery school, kindergarten, first, third, and fifth grade children. The task was a position probe memory test (similar to that used by Kingsley and Hagen, 1969), and no rehearsal instructions were given to any of the subjects. After the completion of the test, subjects were divided into rehearsers and nonrehearsers on the basis of an inquiry into how each child had remembered the correct position of the probed picture. The authors only placed children in the rehearser group if they gave evidence of having used a cumulative rehearsal strategy. Despite the fact that other children indicated that

they had used naming or repetitive naming as an aid in remembering, these children were labeled nonrehearsers.

It was discovered that up to the first grade, children do not appear to make use of cumulative rehearsal. In addition, it was revealed that such a technique did not facilitate overall performance at any grade level. Because of the manner in which these authors separated rehearsers from nonrehearsers it is not correct to assume that cumulative rehearsal had no effect as a memory aid, only that when compared to other forms of rehearsal, it did not prove to be superior.

Studies with the mentally retarded have also supported the position that instructed rehearsal strategies improve recall performance. Kellas, Ashcraft and Johnson (1973) conducted a study with mildly retarded adolescents on two serial recall tasks with familiar pictures. In the first experiment, subjects were randomly divided into one of four conditions: (a) overt rehearsal, free recall; (b) overt rehearsal, serial recall; (c) covert rehearsal, free recall; and (d) covert rehearsal, serial recall. All subjects received typical instructions for either free or serial recall, and those in the overt rehearsal condition were instructed to rehearse the items in any fashion, as long as they did it aloud the entire time the item was visible. Subjects in the covert rehearsal condition did not receive any special instructions.

A typical serial position curve with both primacy and recency effects was produced by all groups, with covert rehearsal resulting in higher primacy than recency, and overt rehearsal producing the opposite effect. Analysis of overt rehearsal data indicated that overall, the level

of rehearsal was relatively low, and that these subjects tended to restrict their information processing to simple naming of the items.

These authors then conducted a second experiment in which they introduced an instructed rehearsal strategy. The four experimental groups in this study were: (a) overt, cumulative instructions; (b) overt, no instructions; (c) covert, cumulative instructions; and (d) covert, no instructions. Cumulative rehearsal was trained by having the subjects "shadow" the experimenter's overt rehearsal, until they could produce such rehearsal behavior on their own. Overt subjects did this aloud and covert subjects rehearsed silently. Subjects in both the overt and covert no instructions conditions were given rehearsal instructions similar to overt and covert free recall in the first experiment.

Again the typical serial position curve was produced by all groups. Cumulative instruction groups showed superior performance in that they reached criterion in fewer trials than the noninstructed groups. Analysis of the overt groups' performance indicated that the cumulative rehearsal group were indeed using a rehearsal set of up to 7 of the 9 items, while the noninstructed group simply named each item as it was presented.

A post hoc decision was made to retest all groups two weeks later, with only self pacing and free recall instructions. No rehearsal instructions were given prior to this retest. Results indicated that subjects in the original cumulative rehearsal conditions continued to use this strategy, and their recall performance was superior to that of the subjects in the noninstructed conditions.

Brown, Campione and Murphy (1974) conducted a similar study with mildly retarded adolescents (mean chronological age = 15.7 years, and mean mental age = 7.9 years) in which the subjects were shown 16 items, four at a time. One of the items was then probed, and the subjects had to remember where it had appeared on a display panel. Half the subjects had previously taken part in a similar experiment and had been trained to cumulatively rehearse the first three items and "Just try to remember" the fourth. The other half of the subjects received no rehearsal training.

The results indicated that the rehearsal group performed significantly better than the no rehearsal group. The same task was given to all subjects six months later as a generalization test, and it was discovered that eight of the ten rehearsal trained subjects had maintained the rehearsal strategy, even though they only received instructions to remember the stimuli, not the rehearsal technique. In contrast to the Hagen, Hargrave and Ross (1973) study, in which preschool children failed to show improved memory performance following rehearsal training, this study demonstrates that intensive training can result in long-term retention of a rehearsal strategy in older retarded children.

It has also been shown that rehearsal training can improve the recall of deaf individuals. Belmont, Karchmer and Pilkonis (1976) compared congenitally deaf high school seniors (median age = 18 years) with normal hearing subjects (median age = 20 years) on a self-paced position probe task with consonant letters. The deaf subjects received four testing sessions, divided so that there was a four to six hour interval be-

tween sessions one and two; three weeks between sessions two and three; and one week between sessions three and four. In the first half of session one, subjects were given six letter lists and no rehearsal instructions. Following this, they were instructed in the use of a three-three cumulative rehearsal technique. This strategy involved fingerspelling the first three test letters as a group, then the last three letters in the same way. Session two duplicated the second half of session one. The third session consisted of more trials under three-three instructions, followed by seven letter lists which were rehearsed in a four-three pattern. Session four stressed rapid, accurate recall, and subjects were given practice lists of seven letters, followed by six letter test lists. The hearing subjects only received two sessions. In the first session they were tested without rehearsal instructions and then trained on both three-three and three-four rehearsal strategies, in which they said the letters aloud. Their second session duplicated the deaf subjects' fourth session.

Results indicated that instructed rehearsal strategies produced gains in primary memory, as indicated by rapid recall of terminal items, and gains in secondary memory, as indicated by improved recall of early items. Although the hearing subjects' recall speed and accuracy were superior to that of the deaf when compared across all conditions, rehearsal training for the deaf caused them to achieve and maintain a level of recall speed and accuracy very close to the hearing group's performance in the no rehearsal instructions condition.

Contrary to this finding however, are those of MacDougall and

Rabinovitch (1971) who conducted a study that compared oral deaf children (mean age = 12 years, 5 months), manual deaf children (mean age = 14 years, 1 month), and normal hearing children (mean age = 11 years, 0 months) on a paired associates recognition task. Half the subjects in each of the three groups were instructed to rehearse the stimuli during the first set of test lists and the other half were instructed to rehearse during the second set of lists. Rehearsal consisted of naming the items as they were presented, either verbally, for the hearing subjects and oral deaf subjects, or in sign language, for the manual deaf subjects.

The results were surprising, in that no difference in the performance between deaf and hearing subjects was found. The majority of memory studies that compare deaf and hearing subjects have limited themselves to tests of recall, and have consistently found evidence pointing to a memory deficit on the part of the deaf. MacDougall and Rabinovitch postulated that the typical memory deficit of the deaf applies to recall but not recognition. The absence of a rehearsal effect was a second unexpected result. These authors suggest that perhaps the nonverbalization groups were covertly rehearsing in the same fashion as the overt rehearsers.

It appears evident from this survey of the literature, that both spontaneous and induced rehearsal during memory tasks facilitates recall performance. Spontaneous rehearsal seldom occurs in very young children, deaf, or retarded individuals, but rehearsal techniques can be taught to such subjects, resulting in immediate gains in recall. That very young

children must be prompted to continue using rehearsal strategies contrasts with the finding that retarded individuals maintained rehearsal behavior six months after training. Developmental differences have been shown to occur both in the amount of spontaneous rehearsal and in the complexity of the strategy. Younger children tend to use naming strategies when they rehearse and older children tend to use cumulative rehearsal. Serial position effects (primacy and recency) appear to be influenced by the type of strategy employed, with retention of early items in a serial list enhanced by cumulative rehearsal whereas a naming strategy enhances recall of the last items in a list.

Memory Processing in the Deaf

With respect to coding mechanisms involved in short-term memory, past studies have led to an agreement that with simple verbal material, the predominant storage mode depends upon acoustic coding in hearing subjects (Conrad, 1962, 1964; Sperling, 1963) but not in the deaf (Conrad, 1970; Conrad & Rush, 1965; Hoemann, Andrews & DeRosa, 1974; Wallace & Corballis, 1973). Even when material is visually presented, errors tend to be acoustically similar to the correct item for hearing subjects (Conrad, 1964). Although deaf children do make consistent errors, they are not acoustic, and may be based on visual shape or manual sign cues (Conrad, 1972; Hintzman, 1965). This finding was supported by Wallace and Corballis (1973), who found that although the deaf are deprived of normal auditory encoding mechanisms, and to some extent are deficient in articulatory and linguistic skills, they appear to compensate for these

deficiencies by developing alternate memory codes.

As to whether deaf children encode categorically in short-term memory as do hearing children, Hoemann, Andrews and DeRosa (1974) found that they do. They noted no significant differences between deaf and hearing subjects and concluded that the deaf child's memory on picture tasks is functionally similar to that of hearing children. This indicated that the central cognitive processes in deaf subjects can function effectively, without acoustic mediators. These authors also found that both the deaf and the hearing encode information relating to the distinctive features of linguistic stimuli: formational parameters of signs (kinesthetic) in the deaf, and phonological cues (auditory) for the hearing.

It was noted by Sperling (1963) that, in addition to an auditory code, hearing subjects can also make use of semantic cues as a means of verbal mediation. Moulton and Beasley (1975) investigated whether the manual deaf use a manual coding system exclusively, or whether semantic relationships might also be involved. Deaf subjects were shown four different lists of word pairs, arranged so that: in List 1, the words shared the same meaning and sign; in List 2, the words had the same meaning but a different sign; List 3 contained words with the same sign but a different meaning; and List 4 was a control, the words having both a different meaning and a different sign. The results indicated that although semantic coding was primary, sign formation relationships were used as a coding system almost as efficiently. Absolutely no auditory coding strategies were observed. These authors concluded that it is pos-

sible that the deaf may be capable of switching codes and that the system they choose to use varies with varying communication situations.

Conclusions

Since rehearsal has been shown to be an effective technique in improving memory performance in hearing children, there is no reason to believe that such a system should not work with the deaf - especially since it appears that they have essentially the same cognitive processes. The fact that the deaf appear to code material kinesthetically makes it clear that sign language can be manipulated in the same way as verbalization, and thus should be an ideal form of rehearsal. Studies comparing deaf and hearing children have agreed that performance of the deaf is usually inferior, but few attempts have been made to remedy this situation. Instructed sign language rehearsal appears to be the obvious solution in light of the findings in this review.

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APPENDIX A

Table 6

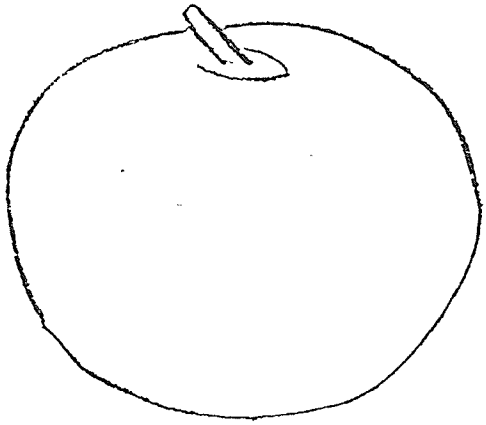
Sets of Stimulus Pictures

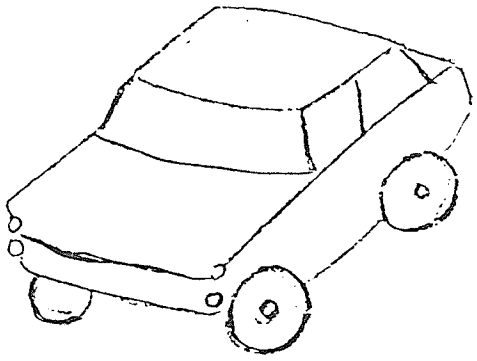
LIST 1	LIST 2	LIST 3
apple	bird	airplane
car	cake	banana
chair	cap	cow
dog	flower	fire
kite	table	pencil
telephone	wagon	shoe

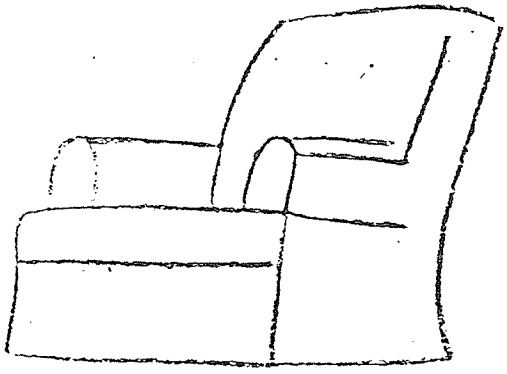
LIST 4	LIST 5	LIST 6
bat	ball	boy
bed	bicycle	bus
bread	boat	fish
pig	eggs	knife
train	frog	scissors
tree	girl	T.V.

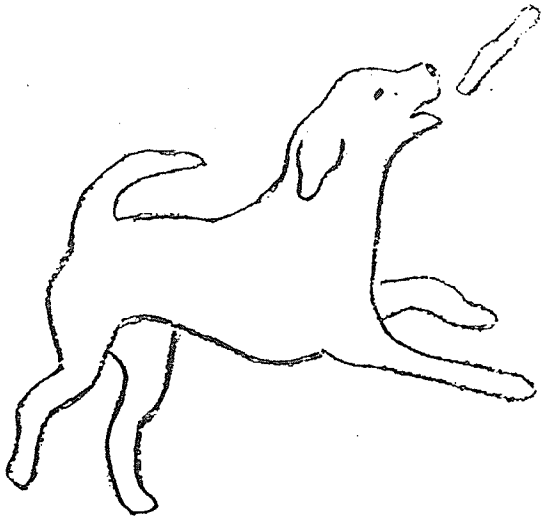
PRACTICE LIST

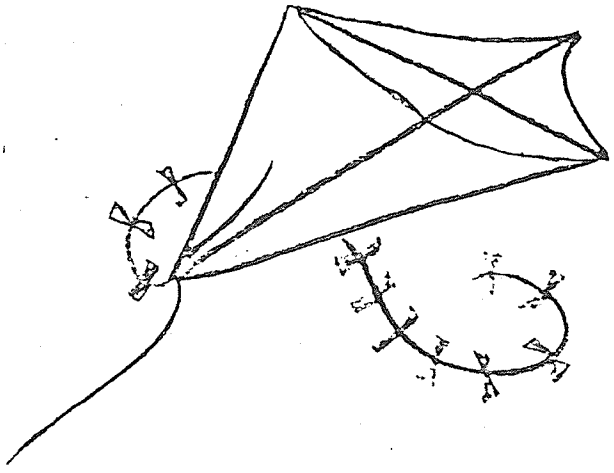
cat
cookie
key
house
horse
watch

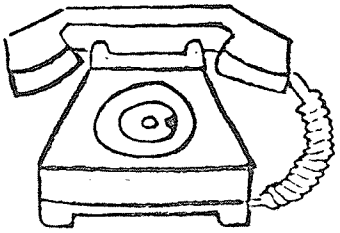


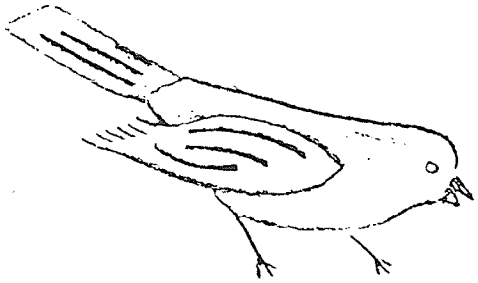


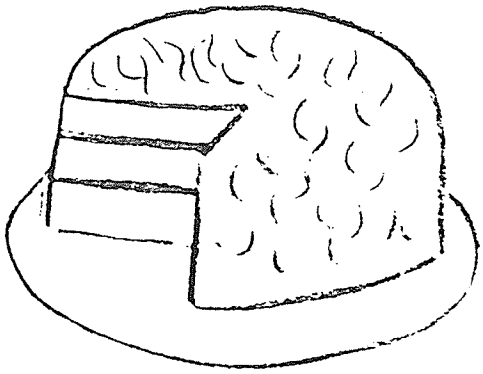


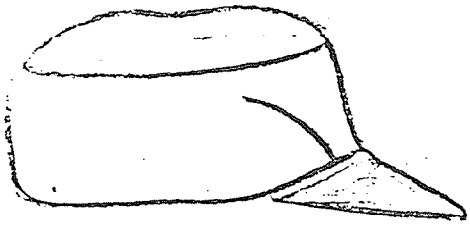


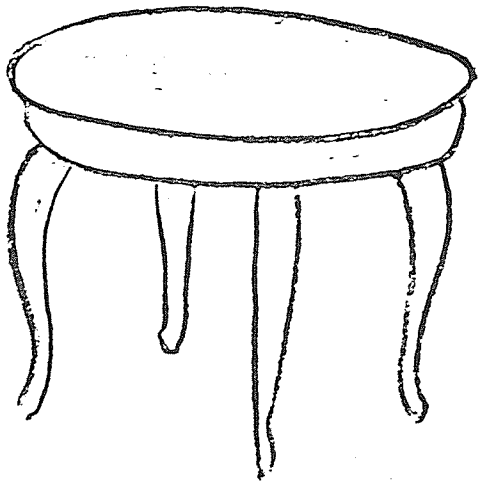


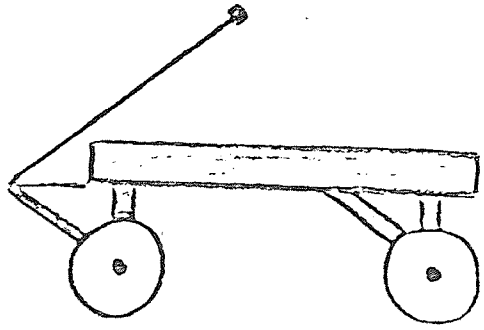


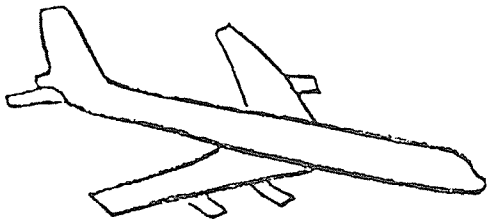


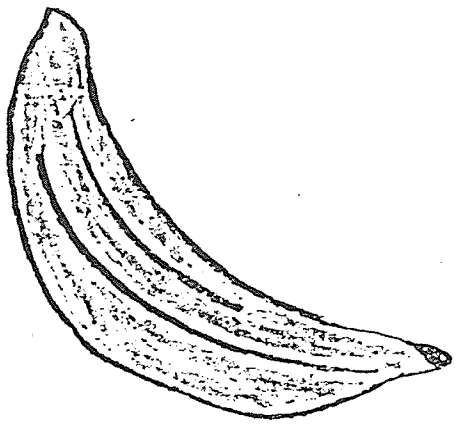


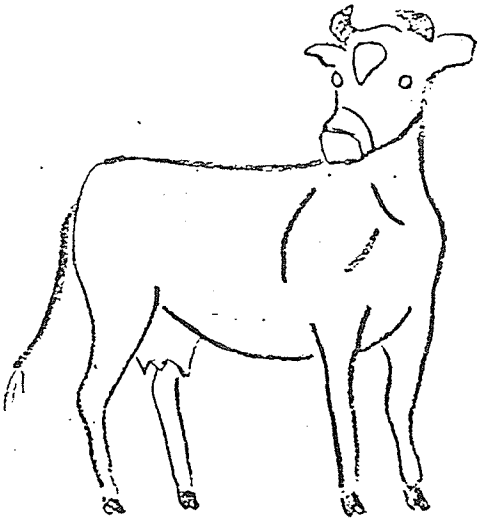


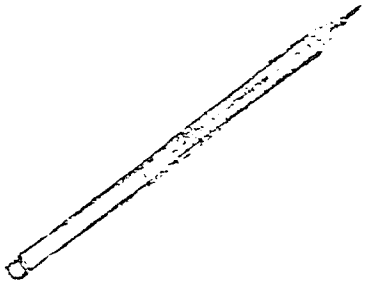


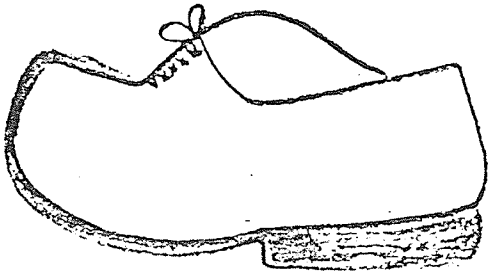




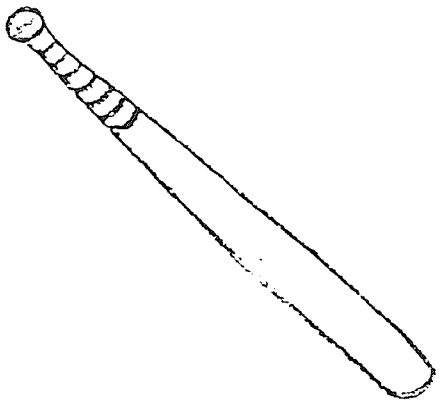


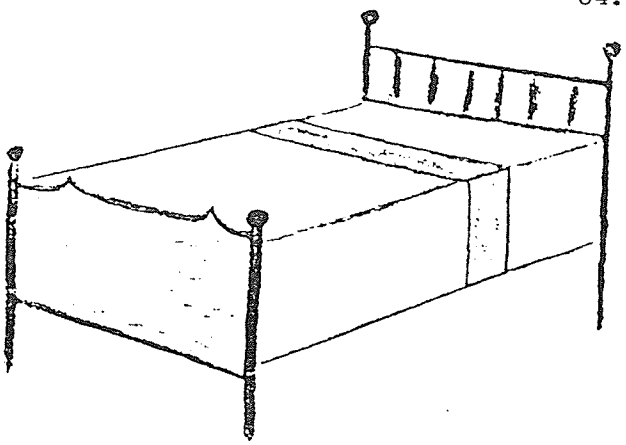


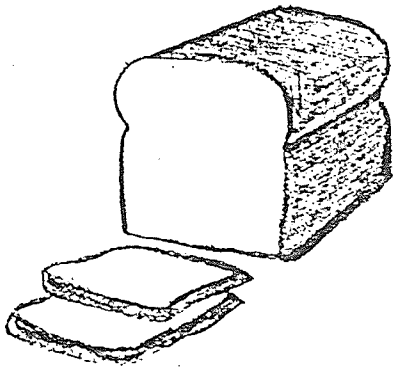


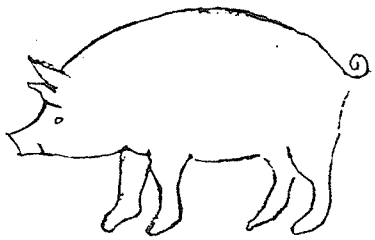


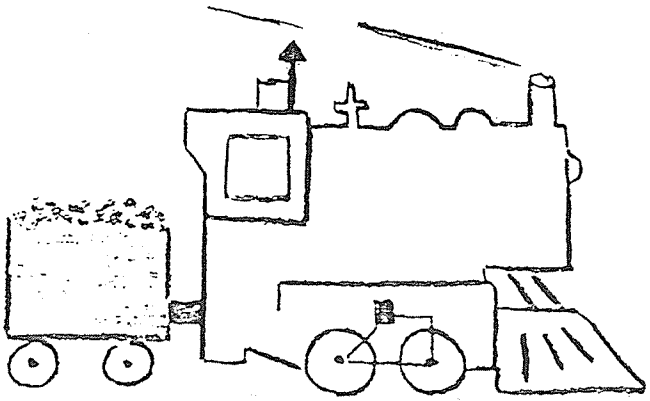
LIST 4

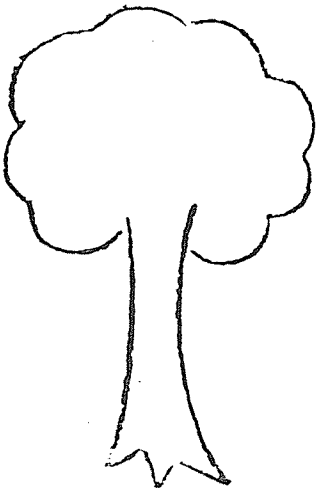


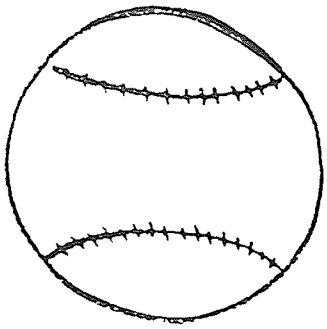


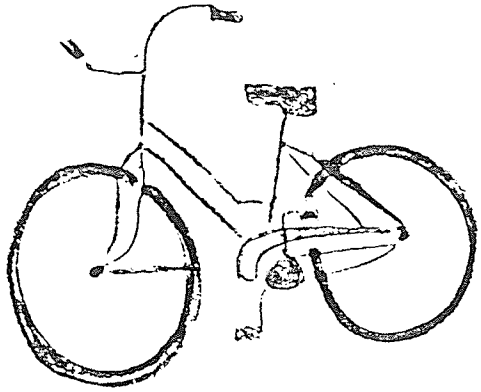


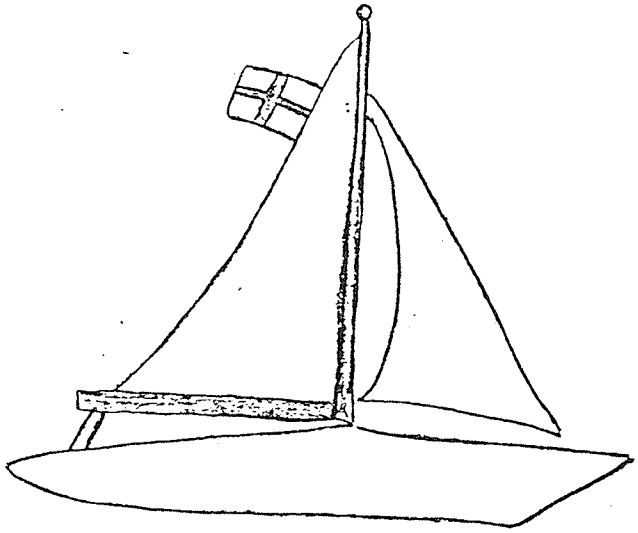


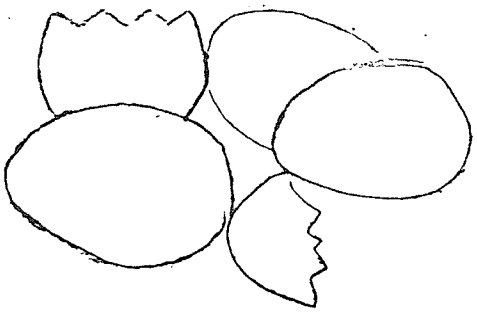


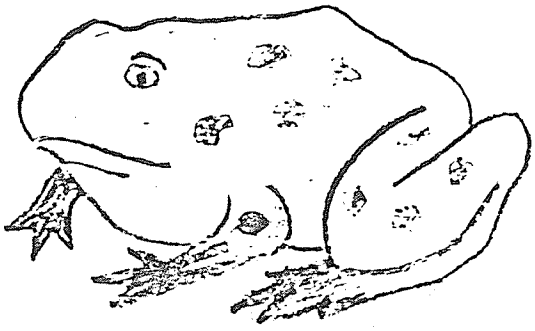


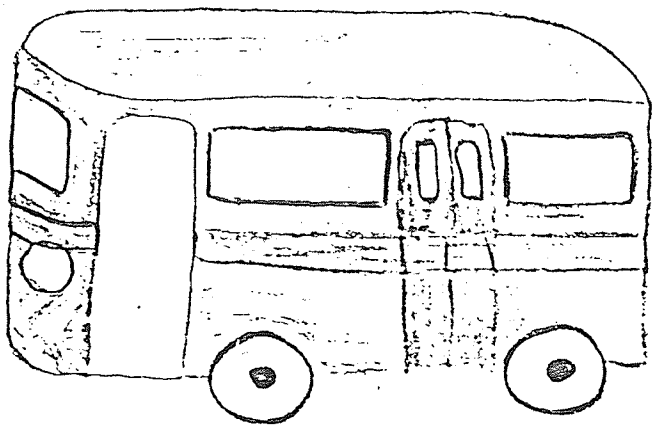


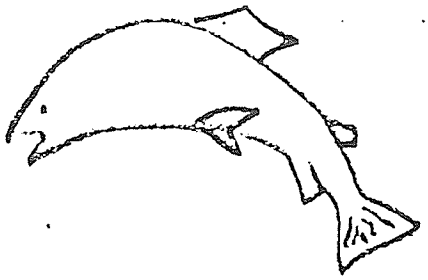


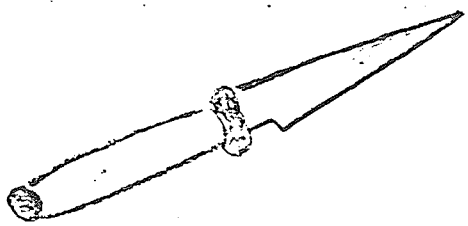


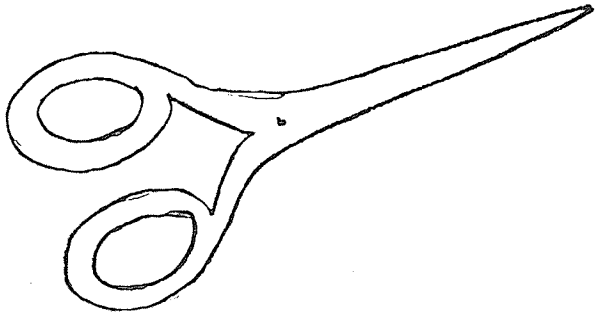


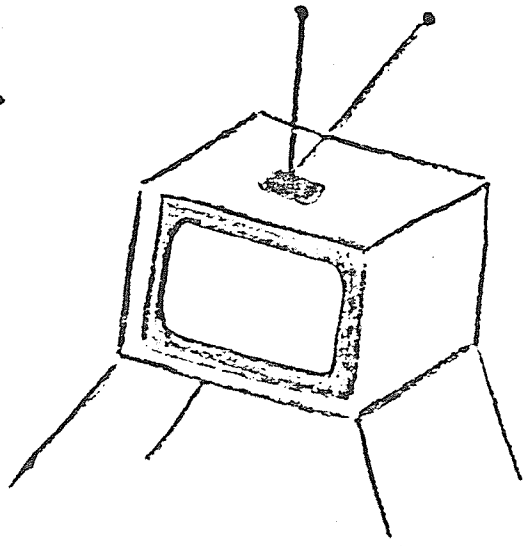


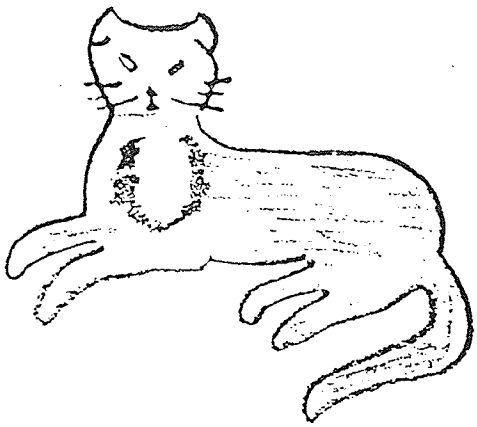


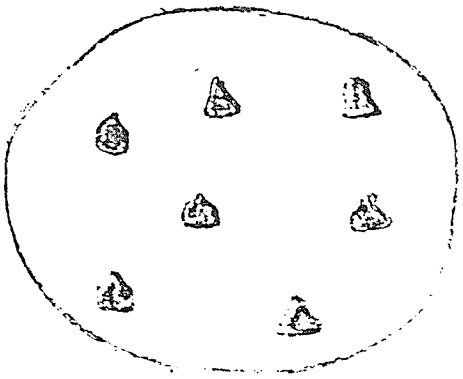


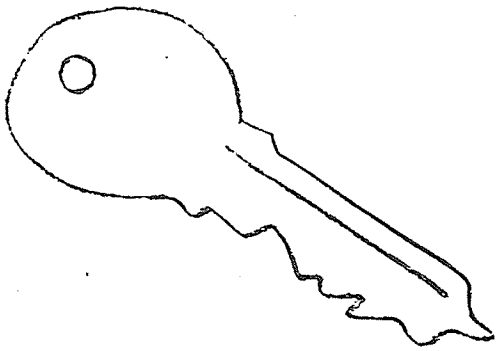


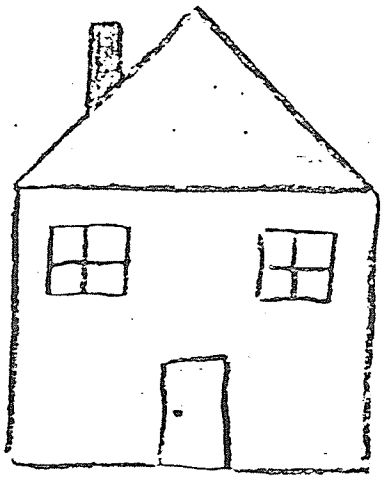


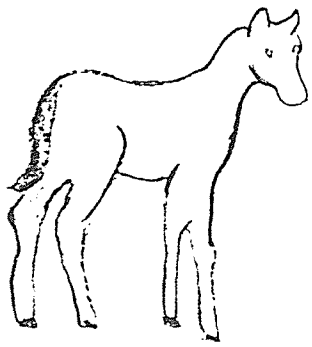


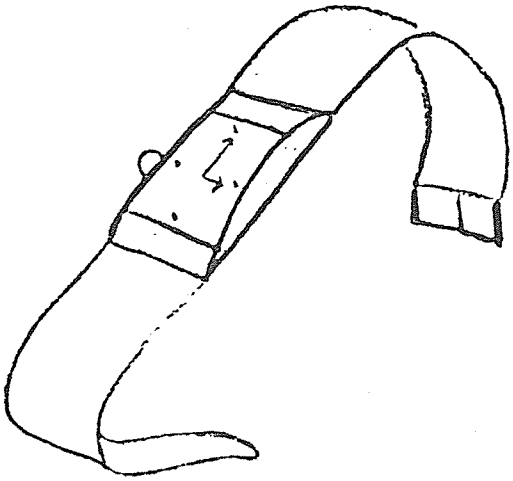












APPENDIX B

Table 7

Summary of the Analysis of Variance of Number of Correct Responses per Trial Block on List 1

Source of Variation	df	MS	F	
Age	1	5.67	4.36	$p < .05$
Condition	1	55.25	42.49	$p < .001$
Number of Lists	1	5.00	3.85	
Age X Condition	1	0.00	0.00	
Age X Number of Lists	1	1.88	1.45	
Condition X Number of Lists	1	1.88	1.45	
Age X Condition X Number of Lists	1	0.42	0.32	
Error	24	1.30		
Trials	5	1.17	1.41	
Trials X Age	5	0.58	0.70	
Trials X Condition	5	0.44	0.53	
Trials X Number of Lists	5	0.79	0.96	
Trials X Age X Condition	5	0.69	0.84	
Trials X Age X Number of Lists	5	1.42	1.71	
Trials X Condition X Number of Lists	5	0.44	0.53	
Trials X Age X Condition X Number of Lists	5	0.38	0.46	
Error	120	0.83		

Table 8

Summary of the Analysis of Variance of Number of Correct Responses per Serial Position on List 1 [1].

Source of Variation	df	MS	F	
Serial Position	5	39.93	30.51	$p < .001$
Serial Position X Age	5	0.52	0.40	
Serial Position X Condition	5	2.73	2.09	
Serial Position X Number of Lists	5	0.30	0.23	
SP X Age X Condition	5	0.45	0.35	
SP X Age X Number of Lists	5	0.55	0.42	
SP X Condition X Number of Lists	5	0.28	0.21	
SP X Age X Condition X Number of Lists	5	0.85	0.65	
Error	120	1.31		

1. df, MS and F ratios for the between subjects factors are contained in Table 7.

Table 9

Summary of the Analysis of Variance of Number of Correct Responses per Trial Block in the Training Phase of the Second Session

Source of Variation	df	MS	F	
Age	1	3.37	2.88	
Condition	1	18.37	15.66	$p < .001$
Number of Lists	1	5.04	4.30	$p < .05$
Age X Condition	1	0.17	0.14	
Age X Number of Lists	1	1.50	1.28	
Condition X Number of Lists	1	1.50	1.28	
Age X Condition X Number of Lists	1	1.04	0.89	
Error	24	1.17		
Trials	2	0.51	1.20	
Trials X Age	2	1.22	2.88	
Trials X Condition	2	0.78	1.84	
Trials X Number of Lists	2	0.01	0.02	
Trials X Age X Condition	2	0.32	0.76	
Trials X Age X Number of Lists	2	0.09	0.22	
Trials X Condition X Number of Lists	2	2.28	5.39	$p < .01$
Trials X Age X Condition X Number of Lists	2	0.95	2.24	
Error	48	0.42		

Table 10

Summary of the Analysis of Variance of Number of Correct Responses per Serial Position in the Training Phase of the Second Session [1].

Source of Variation	df	MS	F	
Serial Position	5	12.56	18.07	$p < .001$
Serial Position X Age	5	1.24	1.78	
Serial Position X Condition	5	0.79	1.13	
Serial Position X Number of Lists	5	0.82	1.18	
SP X Age X Condition	5	0.71	1.02	
SP X Age X Number of Lists	5	0.27	0.40	
SP X Condition X Number of Lists	5	0.22	0.32	
SP X Age X Condition X Number of Lists	5	0.37	0.53	
Error	120	0.69		

1. df, MS and F ratios for the between subjects factors are contained in Table 9.

Table 11

Summary of the Analysis of Variance

of Number of Correct Responses per

Trial Block on List 5

Source of Variation	df	MS	F	
Age	1	5.04	4.87	$p < .05$
Condition	1	18.37	17.76	$p < .001$
Number of Lists	1	0.67	0.64	
Age X Condition	1	0.00	0.00	
Age X Number of Lists	1	0.04	0.04	
Condition X Number of Lists	1	0.37	0.36	
Age X Condition X Number of Lists	1	0.67	0.64	
Error	24	1.03		
Trials	2	0.37	1.02	
Trials X Age	2	3.04	8.26	$p < .001$
Trials X Condition	2	0.12	0.34	
Trials X Number of Lists	2	1.04	2.83	
Trials X Age X Condition	2	0.12	0.34	
Trials X Age X Number of Lists	2	0.04	0.11	
Trials X Condition X Number of Lists	2	1.12	3.06	
Trials X Age X Condition X Number of Lists	2	0.29	0.79	
Error	48	0.37		

Table 12

Summary of the Analysis of Variance of Number of Correct Responses per Serial Position on List 5 [1].

Source of Variation	df	MS	F	
Serial Position	5	9.89	17.17	$p < .001$
Serial Position X Age	5	0.83	1.45	
Serial Position X Condition	5	0.67	1.17	
Serial Position X Number of Lists	5	0.34	0.60	
SP X Age X Condition	5	0.66	1.15	
SP X Age X Number of Lists	5	0.56	0.97	
SP X Condition X Number of Lists	5	0.25	0.43	
SP X Age X Condition X Number of Lists	5	0.17	0.30	
Error	120	0.57		

1. df, MS and F ratios for the between subjects factors are contained in Table 11.

Table 13

Summary of the Analysis of Variance of Number of Correct Responses per Trial Block on List 6

Source of Variation	df	MS	F	
Age	1	1.88	1.16	
Condition	1	47.00	29.08	$p < .001$
Number of Lists	1	3.25	2.01	
Age X Condition	1	4.38	2.71	
Age X Number of Lists	1	1.50	0.93	
Condition X Number of Lists	1	0.25	0.16	
Age X Condition X Number of Lists	1	3.80	2.35	
Error	24	1.62		
Trials	5	1.13	1.32	
Trials X Age	5	1.60	1.88	
Trials X Condition	5	0.25	0.30	
Trials X Number of Lists	5	0.55	0.65	
Trials X Age X Condition	5	1.55	1.82	
Trials X Age X Number of Lists	5	1.33	1.56	
Trials X Condition X Number of Lists	5	0.25	0.30	
Trials X Age X Condition X Number of Lists	5	0.12	0.14	
Error	120	0.85		

Table 14

Summary of the Analysis of Variance of Number of Correct Responses per Serial Position on List 6 [1].

Source of Variation	df	MS	F	
Serial Position	5	40.42	48.28	$p < .001$
Serial Position X Age	5	1.19	1.42	
Serial Position X Condition	5	6.14	7.34	$p < .001$
Serial Position X Number of Lists	5	0.42	0.50	
SP X Age X Condition	5	0.84	1.01	
SP X Age X Number of Lists	5	0.74	0.89	
SP X Condition X Number of Lists	5	0.47	0.56	
SP X Age X Condition X Number of Lists	5	0.58	0.70	
Error	120	0.84		

1. df, MS and F ratios for the between subjects factors are contained in Table 13.

APPENDIX C

Table 15

Raw Scores for Number of Correct Responses per Trial Block on All Lists

* S	A	C	N	TB1	TB2	TB3	TB4	TB5	TB6	L	ID No.
2	1	1	1	6	3	5	5	4	5	1	1
2	1	1	1	6	4	5	6	3	5	1	2
1	1	1	2	4	4	4	6	6	5	1	3
2	1	1	2	4	4	3	6	5	4	1	4
1	1	1	2	4	5	5	5	5	5	1	5
1	1	1	1	4	5	4	3	5	5	1	6
2	1	2	2	5	4	4	5	5	5	1	7
1	1	2	2	4	3	2	4	4	5	1	8
1	1	2	2	3	3	3	4	3	3	1	9
1	1	2	2	5	3	4	2	1	4	1	10
2	1	2	2	3	4	5	5	4	5	1	11
1	1	2	2	4	3	3	4	6	3	1	12
2	2	1	2	3	4	2	3	4	4	1	13
2	2	1	1	6	0	5	5	4	4	1	14
1	2	1	1	5	5	5	3	5	3	1	15
1	2	1	1	6	6	5	5	5	4	1	16
1	2	1	1	5	4	5	4	6	5	1	17
1	2	2	1	6	5	5	5	4	6	1	18
1	2	2	1	5	4	5	6	5	5	1	19
2	2	2	2	4	5	4	5	4	5	1	20
2	2	2	2	6	6	3	4	5	5	1	21
2	2	2	2	5	5	4	5	4	5	1	22
1	2	2	2	2	3	3	5	5	5	1	23
2	2	2	2	5	3	4	4	4	4	1	24
2	2	2	2	2	3	3	4	4	5	1	25
2	2	2	2	4	3	3	4	4	3	1	26
1	2	2	1	2	5	3	4	4	4	1	27
1	2	2	1	4	6	3	5	5	2	1	28
1	2	2	1	2	2	2	4	3	3	1	29
									4	1	30
										1	31
										1	32

* S = Sex: 1 = Male, 2 = Female
A = Age Group: 1 = Younger, 2 = Older
C = Condition: 1 = Rehearsal, 2 = No Rehearsal
N = Number of Training Lists: 1 = 1, 2 = 4
L = Lists: 1 & 2 = Training, 3 & 4 = Generalization

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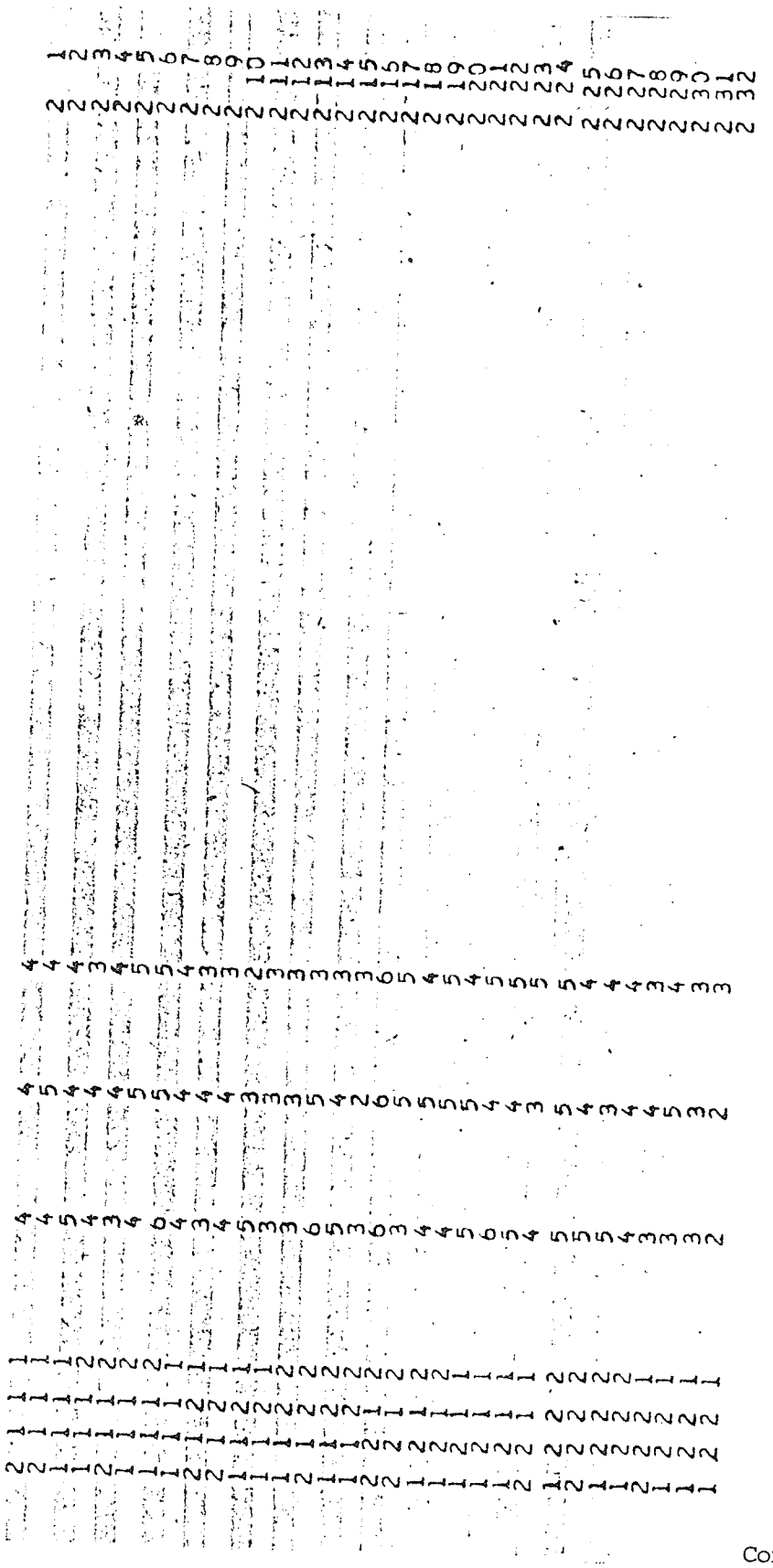

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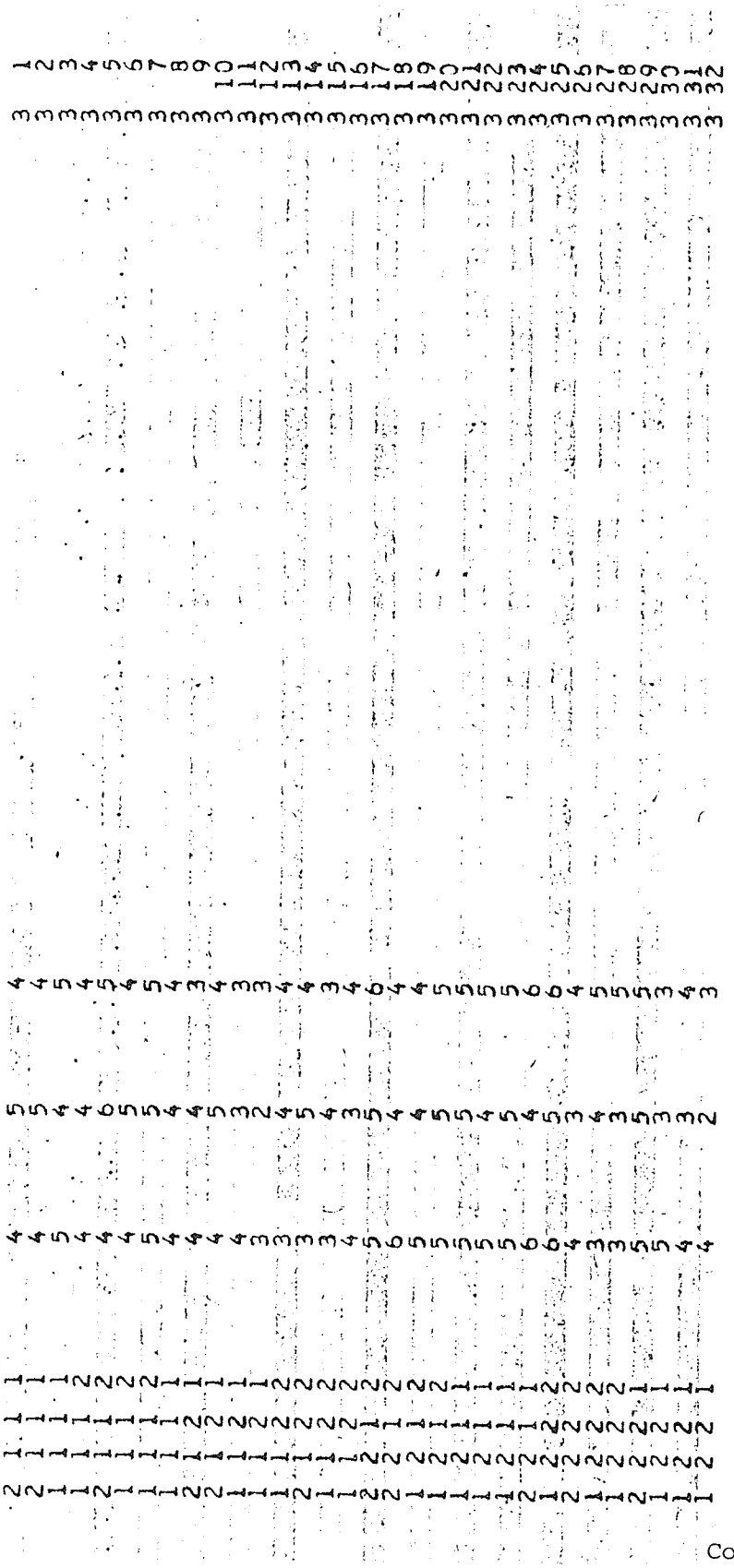

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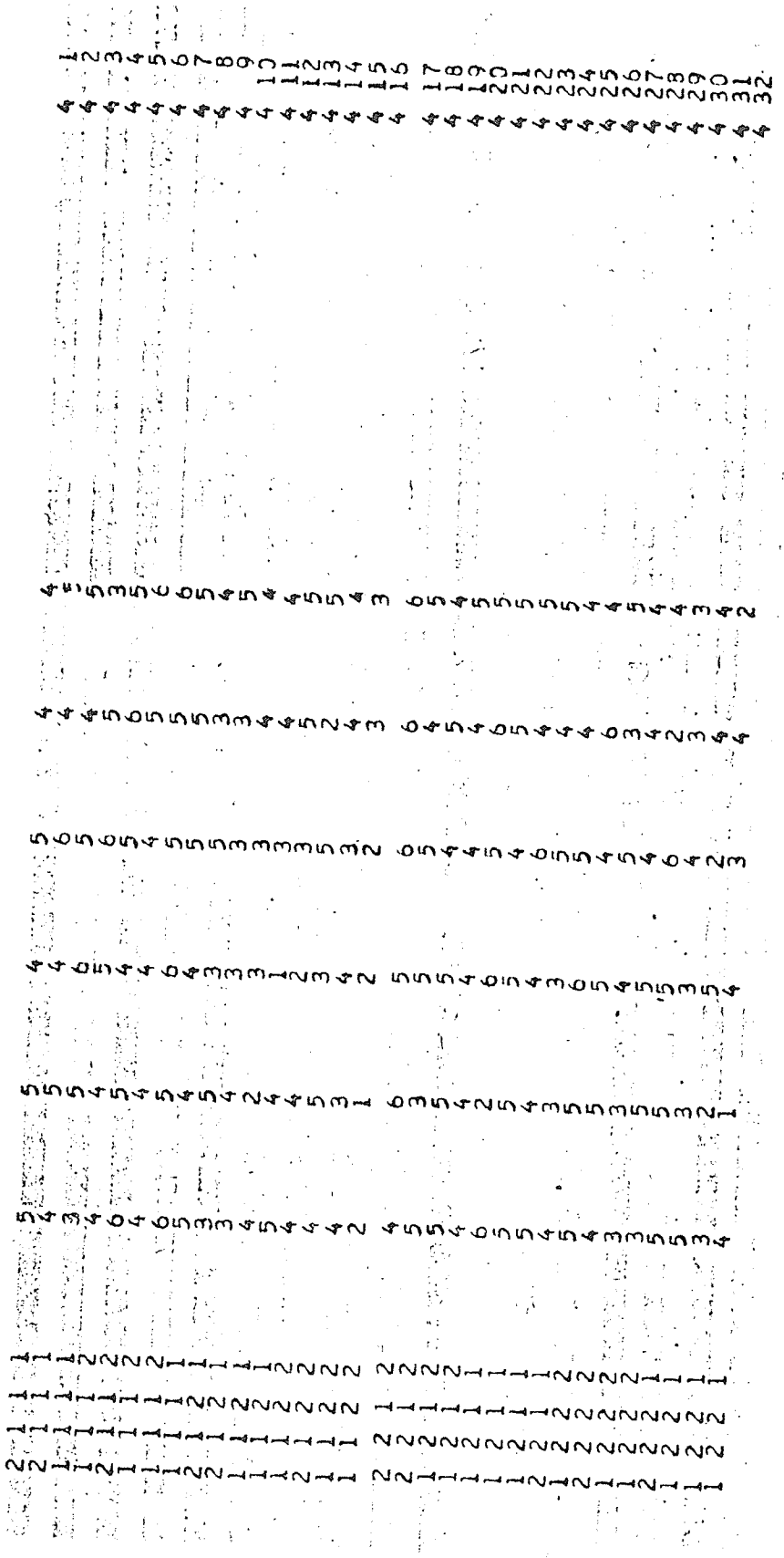

Table 16

Raw Scores for Number of Correct Responses per Serial Position on All Lists

* S	A	C	N	SP1	SP2	SP3	SP4	SP5	SP6	L	ID No.
2	1	1	1	4	5	4	4	5	6	1	1
1	1	1	1	5	5	4	4	5	6	1	2
1	1	1	2	5	5	3	4	6	6	1	3
2	1	1	2	5	4	3	4	4	6	1	4
1	1	1	2	5	6	4	3	4	6	1	5
1	1	1	2	5	4	3	3	6	6	1	6
1	1	1	2	6	2	2	6	6	6	1	7
1	1	1	1	6	4	3	4	4	6	1	8
2	1	2	1	5	3	1	1	6	6	1	9
2	1	2	1	5	2	2	2	3	6	1	10
1	1	2	1	3	4	2	3	1	6	1	11
1	1	2	2	6	1	2	1	5	4	1	12
1	1	2	2	5	4	5	3	6	5	1	13
2	1	2	2	4	3	1	4	3	6	1	14
1	1	2	2	4	3	2	2	4	6	1	15
1	1	2	2	4	4	1	2	5	4	1	16
2	2	1	2	6	4	5	4	6	6	1	17
2	2	1	2	6	5	6	4	6	6	1	18
1	2	1	2	3	5	3	6	6	6	1	19
1	2	1	2	6	4	5	4	6	6	1	20
1	2	1	1	6	6	5	3	5	6	1	21
1	2	1	1	5	4	4	4	5	6	1	22
1	2	1	1	5	4	4	5	6	6	1	23
2	2	2	1	4	2	2	5	6	6	1	24
1	2	2	2	6	4	3	5	5	6	1	25
2	2	2	2	6	5	5	5	5	6	1	26
1	2	2	2	5	3	5	4	4	6	1	27
2	2	2	2	5	2	2	1	5	6	1	28
1	2	2	1	5	2	3	1	5	6	1	29
1	2	2	1	4	6	1	2	4	6	1	30
1	2	2	1	2	1	4	2	5	6	1	31
						0	5	3	6	1	32
						2	1	6	6		
						1					

* See Table 15

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

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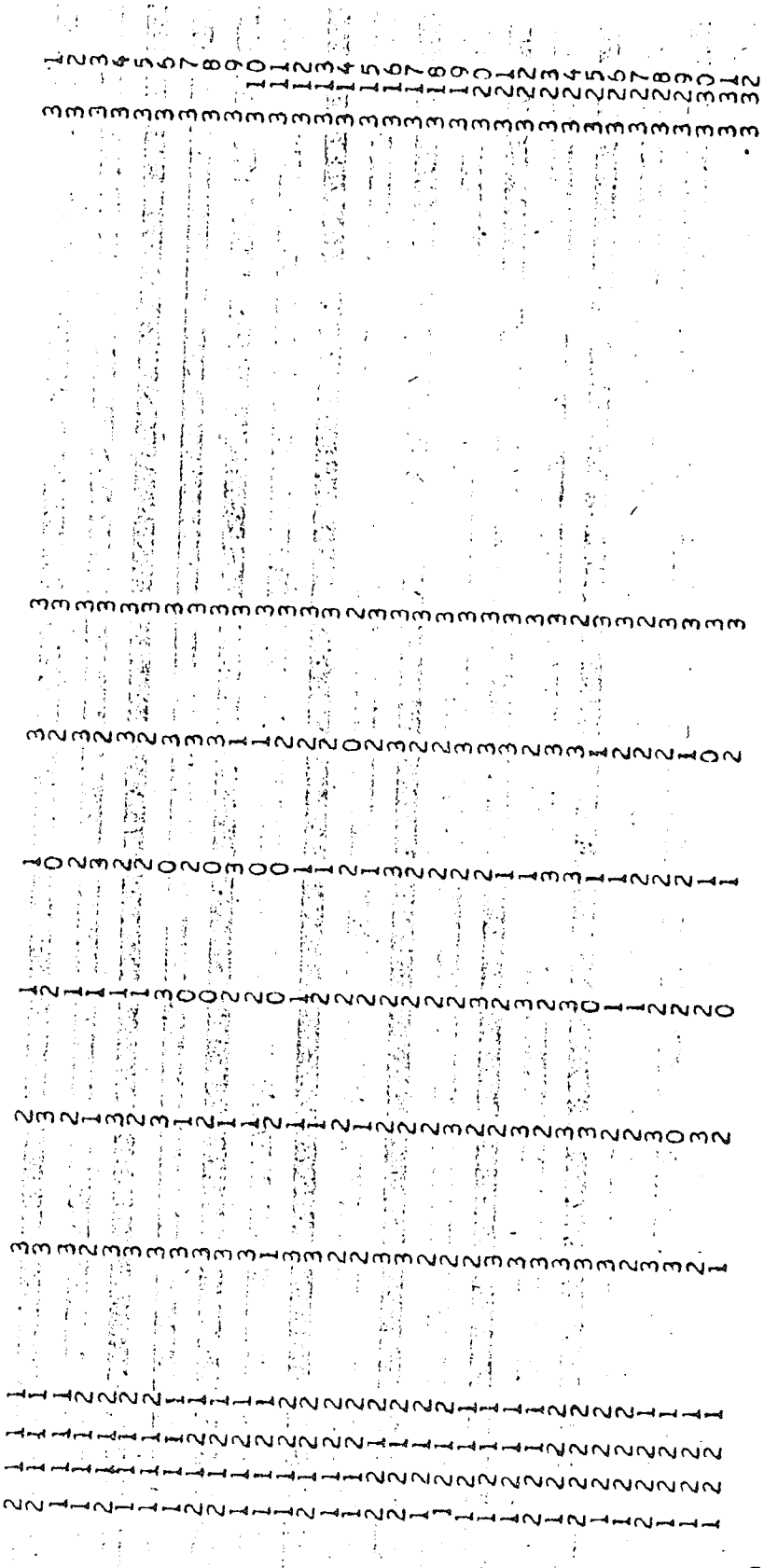

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