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AUTHOR Klein, Pnina S.; Schwartz, Allen A.
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ABSTRACT

To determine if auditory sequential memory (ASM) in young children can be improved through training and to discover the effects of such training on the reading scores of children with reading problems, a study was conducted involving 92 second and third graders. For purposes of this study, auditory sequential memory was defined as the ability to retain auditorily presented information in proper sequence for the purposes of immediate action or recall. The students were assigned to one of four groups: a group receiving training in ASM, a group receiving training for sustained attention to task, a cognitive enrichment group, and a control group which received no treatment intervention. The children were asked to follow oral directions to complete a series of tasks. The directions varied according to the function of the group. The findings indicate that specific training for ASM resulted in improved ASM and that training for attention had a similar effect. Training for attention, however, did not result in reading improvement nor did the control group improve. Reading accuracy scores of the ASM group were higher than those of the other groups, but not significantly higher than those of the cognitive enrichment group. Reading comprehension was not affected differentially by the treatments. (FL)

# Effects of Training Auditory Sequential Memory and Attention on Reading

Pnina S. Klein
Reading/Learning Disabilities Center
Adelphi University

Allen A. Schwartz
Educational Clinic
Queens College, CUNY



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# Effects of Training Auditory Sequential Memory and Attention on Reading

A relationship between auditory sequential memory (ASM), and reading has been demonstrated in recent research revealing disturbances of memory and attention in children with learning disorders (Meriot, 1973; Hirshoren, 1969; Kirk, 1968, Rugel, 1974). Definitions of ASM generally refer to the ability to retain auditorily presented information in proper sequence for the purposes of immediate action or recall (Johnson & Myklebust, 1967). While the construct of ASM has yet to be clearly validated, it has often been operationally defined in terms of specific measurable component skills, i.e. the ability to repeat a sequence of auditorily presented digits (Kirk, 1968).

Auditory sequential memory and attention were found to differentiate significantly between retarded and normal children (Gallagher and Lucito, 1961; Kirk, 1968) as well as between poor readers and normal readers (Bannatyne, 1971, 1974; Rugle, 1974). Errors in sound order (auditory sequence) in reading have been found to discriminate between good and poor readers better than gross reading errors (Senf and Freundl, 1971). The use of ASM for predicting success in reading has been suggested by Chall et. al. (1963) and Hirshoren (1969).

Hirshoren (1969) tested auditory skills in kindergarten children and assessed reading achievement at the end of second grade. He found that the auditory sequential memory subtest on

the ITPA was significantly correlated with the reading tests on the California Achievement Test. Chall, et. al. (1963) reported that sound blending ability (requiring auditory sequential memory) in the first grade was correlated significantly with third grade silent reading.

In a study of 341 children referred for learning difficulties (Meriet, 1973), only 8.7% had difficulties in tasks involving visual perceptual skills and the understanding of spatial relations; 47% had difficulties in tasks involving visual attention and 53% had difficulties in ASM. The memory/attention dimension was suggested in this study as the most valid discriminator between normal children and children with learning disorders.

A factor analytic study of the Wechsler Intelligence Scale for Children (WISC) scores (Bannatyne, 1971, 1974) and a survey of 25 studies on the WISC profiles of children with reading disabilities (Rugel, 1974) indicate that reading disabled children have deficits in the sequential factor or "distractibility" factor involving auditory sequential memory and attention. This pattern of cognitive deficits of children with reading disabilities, found in studies of the WISC, was also reported in studies involving the Illinois Test of Psycholinguistic Abilities (Kirk, 1968).

Birch and Belmont (1964) found that children with reading difficulty have problems in transferring information from one sensory modality to another. These investigators have reported

that poor readers have difficulty repeating a sequence even within the same modality. These findings suggest that the difficulties experienced by poor readers in cross-modal transfer could be explained by poor sequential memory.

Most recently, Badian (1977) investigated the nature of the inferior performance of retarded readers on auditory-visual integration tests. She found that a short-term auditory sequential memory deficit appears to be a major factor in the inferior auditory-visual integration performance of retarded readers.

Auditory sequential memory and attention are closely interrelated. Information presented in sequence necessarily requires the child's attention over that period of time during which the sequence is presented. Thus poor ASM could result from difficulties in attention.

Attention skills in school age children were found to develop with age (Hagan, 1967). The trainability of attention through verbal approval (Fish and McNamara, 1963) and through properties of visual stimuli attended to (Berlyne, 1958; Fantz, 1961; and Hershenson, 1967) have been reported. Although the significance of attention in the learning situation has long been recognized, the problem of attention and educational development is badly in need of further theoretical clarification and research effort (Rohwer, 1970). Since the studies reported on ASM and reading were of a correlational nature, one

can only speculate at the present time as to any cause and effect relationship between ASM and academic achievement. It was the goal of the present study to examine the possible relationship between ASM training and reading improvement.

The training of auditory skills in the remediation of reading problems has been suggested before (Deutsch, 1964; Durrell and Murphy, 1963; Weiner, 1966, Wepman, 1960). However, none of these programs attempted to train and evaluate the specific skills associated with auditory sequential memory. The present study was, therefore, designed to explore the following two questions: (1) Can auditory sequential memory in young children (operationally defined as digit retention) be improved through training on related tasks?, and (2) What are the effects of such training on the reading scores of children with reading problems?

## METHOD

### Subjects

The subjects were 92 second and third grade pupils attending four schools in Queens, New York. The children came from predominantly middle class families. All subjects had a Verbal IQ of at least 84 on the Peabody Picture Vocabulary Test (PPVT), were reading at least one grade below grade level and were significantly below average on two measures of ASM. The sample included 33 females and 59 males. There were 54 second graders with a mean age of 7-8, and 38 third graders with a mean age of 8-7.

Procedure

Screening and Pretesting. Teachers of second and third grades in the four schools were asked to list the children who were behind grade level in reading. These children were then tested individually on the following measures: The Gilmore Oral Reading Test, the Digit Span subtest of the Wechsler Intelligence Scale for Children Revised (WISC-R), and the Auditory Sequential Memory Test from the Illinois Test of Psycholinguistic Abilities (ASM-ITPA). This screening procedure permitted the identification of 95 subjects out of a total of 183 who were reading below grade level (mean reading deficit was 2.1 grades), and who also scored below average on both measures of ASM (mean Digit Span scaled score was 6.3; mean ASM-ITPA scaled score was 30.2--mental age equivalent of 5-8).

The following instruments were subsequently administered to each subject in a second individual testing session: The Peabody Picture Vocabulary Test as a general estimate of verbal ability and intelligence, the Coding subtest of the WISC-R as an additional measure of sequential ability, the Wepman Auditory Discrimination Test to identify significant auditory perceptual deficits, the Knox Cube Test of continuous visual attention as a measure of attention and distractibility, the Hiskey-Nebraska Test of visual sequential memory for digits, and the Arithmetic test from the Wide Range Achievement Test, as an estimate of arithmetic ability.

On the basis of the data gathered from the testing, three children whose IQ scores were below 85 on the PPVT were eliminated from the subject group. The remaining 92 children comprised the sample of subjects who participated in the study.

Training. Following the selection procedure, the subjects were randomly assigned to one of the following four groups: The Auditory Sequential Memory group, the Attention group, the Cognitive Enrichment group and the Standing Control group. Based on an analysis of variance, no significant differences were found between these groups on any of the measures used in the pretesting.

Group 1. The Auditory Sequential Memory (ASM) group. The children in this group received training in ASM. Although the operational definition of ASM in the present study refers only to memory for digits, the ASM training did not include the direct training of this specific skill. Such training would have constituted training for testing. Rather, the ASM training exercises paralleled the digit repetition task, in that most exercises incorporated the following three features: (1) auditory input, (2) immediate recall, and (3) retention of sequence. The objective for this group was to increase the number of units (sounds, words, sentences, directions) a child could retain in short-term memory and retrieve in the correct sequence. The criterion of success was the number of items remembered and recalled from immediate memory. The materials used were designed and presented in a manner to fit the cognitive level, motivation,

and interests of second and third graders (Klein and Schwartz, 1977).

Group 2. The Attention group. The children in this group received training for sustained attention to task. The objective for this group was to increase the subject's ability to selectively direct his focus on task activities or materials, and to avoid being distracted by stimulation extraneous to task performance. Criteria of success were the number of errors, omissions, or commissions on the task. The rationale for including an Attention group was to enable the isolation of the effects of training for attention inherent in the training of ASM; additionally, it permitted the study of the trainability of attention.

Materials and activities used in the training of attention in group 2 were adapted from those used for the training of ASM in group 1. This procedure allowed for a comparison of effects of the two training procedures with relative control over the content of materials and activities.

Group 3. The Cognitive Enrichment (Cognitive) group was designed as a play group in order to control for the effect of the adult-child interaction in small groups which occurred in the training of both ASM and attention. In addition, the training in groups 1 and 2 both necessarily provided a degree of verbal interaction and cognitive facilitation; therefore the Cognitive group engaged in a variety of cognitive and linguistic enrichment activities using materials similar to those used

in groups 1 and 2, but not specifically directed toward the training of either ASM or attention. Sample activities for this group included exercises in spatial relations and right-left discrimination, making up stories to a series of pictures, color and object identification, etc.

Group 4. The Standing Control (Control) group. The children in this group did not receive any treatment intervention other than the testing. This group was designed to measure changes occurring as a result of maturation and regular school activities.

The training of subjects in groups 1, 2, and 3, was accomplished in half-hour sessions carried out three times a week in an isolated room in the school. A single trainer conducted the training sessions for all three groups. The training groups were composed of five or six of the subjects, randomly assigned from the screened sample. The order of the training groups varied from one week to another within each school; this permitted control over the variable related to time of training, and insured that no group consistently missed any regular school activity more often than the other groups. The training program was carried out for 25 sessions, spanning a ten week period, from February to April. The children's regular classroom teachers were not informed about the nature of the training their pupils were receiving.

A behavior modification model (Gardner, 1974) was used throughout the training programs for groups 1, 2, and 3. Each child progressed in the training program designed for his group

in accordance with his achievement on each of the tasks involved. Extrinsic reinforcements in the form of "stars" (exchangeable for prizes and candy) were utilized in order to sustain interest and motivation, and reward successes, on the various learning tasks.

The following are examples of pairs of activity types involving similar materials, one of which was geared toward the training of ASM and the other toward the training of attention.

Example 1. In ASM training the child was asked to follow a series of verbally presented directions. In attention training the verbally presented directions were used in isolation (no sequence); the child was asked to attend carefully to the trainer and follow the direction only if it was followed by a certain word or other code previously agreed upon by the group. This activity was similar to the children's game "Simon Says."

Example 2. In ASM training the child was asked to draw a line connecting a series of different colored dots on a worksheet containing many colored dots. In attention training the same worksheet was used, but directions were geared toward the training of attention rather than sequential memory; children in the attention group were asked to choose and connect dots of one color only and not to omit any.

Example 3. In ASM training the child was asked to repeat from memory a series of landmarks on the way to "Johnny's school" (these landmarks were presented verbally, together with

drawings of the landmarks). In attention training the same drawings were used to designate "stops" on the way to "Johnny's school." Children could only proceed from one landmark to the next by attending to various signals indicating "stop," "go forward one landmark," "go back two landmarks," etc.

Post-training Evaluation. Upon completion of the 25 sessions in each training program, subjects in groups 1,2,3, and 4 were retested on all screening and pre-test measures. The tests were administered individually in a session lasting approximately one hour. Testers were kept blind concerning the treatment assignment of the subjects they tested, and subjects were assigned to testers on a random basis. No significant differences ($p < .05$) were found between the subject groups on any of the administered tests prior to the training.

## RESULTS

The post training test scores of all subjects were analyzed by means of a three way analysis of variance (treatment x grade x sex). This analysis was carried out separately for each of the variables measured. Since no significant differences were found between the four participating schools, the data from all four schools were pooled for analysis. The analysis of the ASM variable was carried out separately for the following four scores: a) The Digit Span from the WISC-R (DS), b) The Digit Span Forwards, from the WISC-R (DS-F), c) The Digit Span Backwards, from the WISC-R (DS-B), and, d) The ASM subtest from the ITPA (ASM-ITPA).

In comparing the DS scores of each of the four participating groups, a main effect for treatment was found ($F = 2.82$,

df = 3/76, $p < .05$). The subjects in the ASM group obtained the highest DS scores as compared with the other groups (see Table 1). The Tukey test for the location of significant differences revealed that the DS scores of the ASM group were significantly higher than those of the Cognitive and Control groups but not of the Attention group. The findings for the ASM-ITPA are in line with those for DS, i.e., a main effect for treatment was found ($F = 2.87$, df 3/76, $p < .05$) with the ASM group scoring higher than the Cognitive and Control groups but not significantly higher than the Attention group. A main effect for treatment was found for DS-F ($F = 2.91$, df - 3/76, $p < .05$) with the ASM group having obtained significantly higher scores than all other groups. No main effect was found for DS-B. ($F = 1.85$, df = 3/76, $p > .05$).

A significant treatment by grade interaction was observed for DS, DS-F, and ASM-ITPA, indicating that second graders in the ASM group obtained the highest scores on DS ($F = 3.94$, df = 3/76, $p < .05$) DS-F ($F = 2.97$, df = 3/76, $p < .05$) and ASM-ITPA ($F = 3.23$, df = 3/76, $p < .05$).

The reading scores were analyzed separately for both Reading Accuracy and Reading Comprehension. The analysis of variance for Reading Accuracy showed a main effect for treatment ($F = 4.21$, df = 3/76, $p < .01$) with the highest scores obtained by the ASM group. The Tukey test for the location of significant differences revealed that the Reading Accuracy scores of the ASM group were higher than those of the Attention group and the Control group but only approached significance ($p < .07$) in comparison with the Cognitive group.

No significant differences between the groups were found with regard to the reading comprehension scores ($F = 1.04$, $df = 3/76$, $p > .05$)

Visual sequential memory for digits was found to be significantly higher in the ASM group as compared to all other groups ($F = 3.72$, $df = 3/76$, $p < .05$)

A significant main effect for treatment was found for the Auditory Discrimination Test ($F = 2.88$, $df = 3/76$, $p < .05$), with both the ASM and the Attention groups obtaining less errors in discrimination than the other groups. No significant differences were found between the groups on any of the following variables: PPVT, Coding, Continuous Visual Attention and Arithmetic. It should be noted that no main effect or interaction involving sex was found for any of the measures used.

## Discussion

The present study examined the possibility of training ASM in second and third grade children and the effects of this training on reading.

Based upon the findings, it may be concluded that ASM, as measured by the WISC-R Digit Span and the Auditory Sequential Memory Test on the ITPA, can be improved through a relatively short period of training. The group which received specific training in ASM scored highest on ASM measures. The Attention group was found to have obtained DS and ASM-ITPA scores which were not significantly lower than those of the ASM group, suggesting that the overall training for attention had a similar

effect on ASM as direct ASM training. However, the ASM training was found to be most effective in raising ASM scores of the second graders above all other groups including the second graders in the Attention group. This finding indicates a special effect of the ASM training as compared with the Attention training. The observed interaction between training effectiveness and grade level suggests that the younger subjects were more sensitive to the ASM training intervention than the older ones.

The transferability of the ASM training from auditory to visual memory was indicated by the finding that significantly higher scores in visual sequential memory were found only in the group that received the ASM training.

Training of Attention did not result in reading improvement nor did the Standing Control group improve. The Cognitive group and the ASM group did not differ significantly with regard to reading accuracy scores. The Cognitive group was engaged in activities traditionally considered as language enrichment or readiness programs and thus could have had a more facilitating effect on reading than the Control and Attention groups. The reading accuracy scores achieved by the ASM group were however generally greater than those obtained by any of the other groups. (See Table 1).

The present study sought to examine the relationship between ASM and reading by first training in a controlled manner for ASM and then observing the effects of this training on reading

scores. The obtained finding of greater reading accuracy improvement in the ASM group as compared with two of the other groups confirms the hypothesis about the relationship of ASM and reading improvement. Of note, however, is the finding that while reading accuracy scores were raised through the ASM training, reading comprehension scores were not significantly affected. This observation may indicate that auditory sequential skills relate more directly to the immediate information processing requirements intrinsic to oral reading accuracy, the "mechanics" of reading, one could say, than to the long term memory requirements and other cognitive processes intrinsic to answering comprehension questions about the contents of a passage read aloud. It is possible that comprehension may have been positively affected had the duration of ASM training been extended, making reading accuracy more automatic and thereby freeing the child to engage in the processes necessary for comprehension. Equally likely, however, is that reading comprehension involves abilities less immediately affected by ASM improvement and more related to abilities involved with the organization of a meaningful whole, and its recall from long term memory. This question requires additional study before a definitive answer may be offered.

The groups receiving training in either ASM or attention were the only training groups improving significantly in auditory discrimination. The attention training, which called for the careful distribution of attention between target stimuli and environmental distractors, was expected to positively

affect an ability like auditory discrimination. The finding that the training of ASM also produced an improvement in auditory discrimination suggests that in training for ASM, attentional skills may also be developed, thereby enhancing auditory discrimination as a by-product.

It should be noted that no training exercise included in the present study involved actual reading or any activities calling for sequential memory for digits. Thus, the observed differences between the groups in ASM and reading accuracy may not be attributed to direct practice on either of the criterion tasks. In no way were the children specifically trained for these tests.

In summary, the present study indicates that ASM may be trained, especially in younger children. This training appeared to coincide with higher scores in reading accuracy but had no effect on reading comprehension.

Table 1

Mean post training scores of the 2nd and 3rd graders in the four subject groups, on all measures used

| Subject Group | Grade | Auditory Sequential Memory | | | | Reading (Grade Scores) | |
|---|---|---|---|---|---|---|---|
| | | DS | DS-F | DS-B | ASM-ITPA | Accuracy | Comprehensi |
| ASM N=25 | 2nd n=14 | 9.4 | 9.9 | 9.0 | 37.2 | 2-4 | 2-6 |
| | 3rd n=11 | 8.2 | 8.2 | 8.2 | 35.3 | 3-2 | 3-2 |
| Attention N=22 | 2nd n=14 | 7.8 | 8.0 | 7.8 | 30.2 | 1-9 | 2-4 |
| | 3rd n=8 | 7.5 | 8.0 | 7.0 | 32.5 | 2-8 | 3-4 |
| Cognitive N=21 | 2nd n=13 | 6.4 | 6.4 | 6.5 | 28.1 | 2-2 | 2-8 |
| | 3rd n=8 | 6.6 | 6.4 | 6.8 | 28.7 | 3-1 | 3-2 |
| Control N=24 | 2nd n=14 | 6.4 | 6.8 | 6.2 | 27.4 | 1-9 | 2-3 |
| | 3rd n=10 | 6.8 | 7.2 | 6.5 | 28.8 | 2-7 | 3-0 |

* lower score indicates better performance

Table 1

| Visual Sequential Memory (Grade Scores) | Auditory Discrimination | Continuous Visual Attention | PPVT | Coding | WRAT Arithmetic |
|---|---|---|---|---|---|
| 2-8 | 2.5 | 2-7 | 102.1 | 8.8 | 100.3 |
| 3-5 | 2.8 | 3-7 | 102.3 | 9.0 | 96.1 |
| 2-2 | 3.0 | 3-0 | 99.6 | 9.1 | 100.7 |
| 2-9 | 2.7 | 3-5 | 98.2 | 9.4 | 102.8 |
| 2-0 | 4.5 | 2-4 | 101.0 | 9.0 | 94.5 |
| 2-7 | 4.1 | 3-0 | 102.9 | 8.8 | 99.6 |
| 1-9 | 4.6 | 2-4 | 99.3 | 8.7 | 101.4 |
| 2-8 | 4.6 | 3-1 | 101.0 | 8.9 | 98.4 |

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Requests for reprints should be sent to: Dr. P. S. Klein, Reading/Learning Disabilities Center, Adelphi University, Garden City, N.Y. 11530.