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The Effects of Three-Dimensional Objects vs. Two-Dimensional Objects in a Serial Positions Task on the Short-Term Memory of Elementary School Children With Low Intelligence

Alice Dye Maechtlen

THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO 87106

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This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

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THE EFFECTS OF THREE-DIMENSIONAL OBJECTS VS. TWO-DIMENSIONAL OBJECTS IN A SERIAL POSITIONS TASK ON THE SHORT-TERM MEMORY OF ELEMENTARY SCHOOL CHILDREN WITH LOW INTELLIGENCE

Title

ALICE DYE MAECHTLEN

Candidate

SPECIAL EDUCATION

Department

John F. Zepper

Dean

May 8, 1973

Date

Committee

Billy L. Watson

Chairman

Daniel B. Berch

Glen Van Etten

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BY
ALICE DYE MAECHTLEN
B.A., Cleveland State University, 1969

THESIS

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The purpose of this study was to determine the effects of three-dimensional stimuli versus two-dimensional stimuli in a serial positions task on the short-term memory of elementary school children with low intelligence. The specific hypothesis was that elementary school children with low intelligence would have greater short-term memory response accuracy on a serial positions task with three-dimensional objects than with two-dimensional objects.

Fourteen fourth, fifth, and sixth graders whose IQ scores ranged from 60 to 85 were selected from regular classrooms in a middle income area in Albuquerque, New Mexico. Each subject was given the serial positions task with the two-dimensional objects and the task with the three-dimensional objects. Half received the two-dimensional objects first and half received the three-dimensional objects first. The two-dimensional objects were pictures and the three-dimensional objects were the actual items that were pictured. Five of the stimulus items were shown to the subject in succession and then turned facedown or covered with small boxes. The subject was then asked to find the item that looked like the duplicate stimulus item presented by the experimenter.

Results of this study indicated that elementary school children with low intelligence did better on a serial positions task when the stimulus items were three-dimensional than when the stimulus items were two-dimensional. A correlated $\underline{t}$ test showed the results to be significant at the .01 level.

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I

INTRODUCTION

The purpose of this study is to investigate the effects of three-dimensional stimuli versus two-dimensional stimuli on the short-term memory of elementary school children with low intelligence. Much research supports the theory that the learning problem of the child of low intelligence is in short-term memory. Ellis (1963) reviewed the literature dealing with the stimulus trace in memory. According to Ellis there is evidence from neurophysiology of a reverberatory circuit in short-term memory. The stimulus trace is an actual physical aftereffect of the stimulus. Ellis accepted the theory of an inadequacy in the stimulus trace as a major problem in the functioning of mental subnormals. Hermelin & O'Connor (1964) suggested that this inadequacy is caused by a stimulus trace of less duration in subnormals than in normals. Apparently individuals of low intelligence forget faster due to a shortened trace perseveration time.

Ellis (1970) discussed the primary and secondary processes that make up short-term memory. Primary memory involves the reception of the stimulus and has a limited capacity. Information is transfered from primary memory to secondary memory by means of rehearsal strategies. Secondary memory stores the information for a longer period of time, but for no longer than a few minutes. From secondary memory the information is transfered to permanent storage by rehearsal strategies, or it is discarded. According to Ellis, McCarver, & Ashurst (1970), individuals of subnormal intelligence seem to lack the rehearsal skill that is an important part of the short-term memory processes. Belmont & Butterfield (1969) also stated that less intelligent individuals have a deficit in short-term memory. This deficit is due to a problem in acquisition (or possibly retrieval) of information.

In actual testing of the learning and memory of children with low intelligence, many researchers have found indications of this deficiency in short-term memory. Underwood (1954) did a study in which there was no difference in rate of forgetting of fast and slow learners when suitable methodology was used to reach the criterion level of the original learning. The difference in learning was in the acquisition of information in short-term memory. Calfee (1969) found increments in initial performance level with increasing age and IQ, as did Belmont & Butterfield (1969). However, once the task was thoroughly learnedhe found little evidence that forgetting occurred at a faster rate in younger or less intelligent children. O'Connor & Hermelin (1963) also found no differences in learning or memory scores between normals and retardates when they experimented with the method of stimulus presentation and the types of stimulus items.

A standard procedure for obtaining data on the memory of young children or children with low intelligence is through the use of paired-associates lists. Rohwer (1972) added an element when he used actual objects in conjunction with his paired-associates task. However, there are many drawbacks to this method of gathering data. Initial learning is involved before memory can be tested. After discussing some of the problems involved in experiments of the paired-associates type, Scott (1971) encouraged the use of a matrix of pictures. An even more straightforward design is that developed by Atkinson, Hansen, & Bernbach (1964). Rather than have the child learn a list and then remember it, Atkinson asked the child to remember the serial positions of facedown playing cards that he had seen faceup only seconds before. This method eliminates the variable of learning and deals directly with short-term memory.

Although the serial positions procedure is more appropriate for testing short-term memory in children, the analysis of the results involves some problems. Calfee (1970) found considerable position bias in children's response behavior. In discussing position bias, Ellis & Munger (1966) stated that there is a strong tendency for children to respond to the middle position. Donaldson & Strang (1969) also stressed that the primacy and recency effects, along with the position bias, must be taken into account when considering data from a serial positions task. Murdock (1966) explained the use of signal detection theory in analyzing the results in a test of memory. It has been incorrectly assumed that the subject's response is either correct or a guess. There are a number of factors, other than guessing, that could cause an incorrect response. Signal detection theory says that there are two major factors involved in every response in a test of detection or memory. The response is a function of both the subject's sensitivity to the stimulus (detection) and his own subjective criteria (decision).

Signal detection theory uses the d' statistical value (Hochhaus, 1972) to consider instances when the subject answers "yes" and is correct (hit) and also instances when the subject answers "yes" and is incorrect (false alarm). For example, the subject may decide that he will answer, "Yes, I have seen that picture before," only when he is absolutely certain that he has seen the picture. He will make few "yes" answers when the correct response is "no." And he will make many "no" answers that are correct (correct rejection). But he will also make more "no" responses when the correct response is actually "yes" (miss) than a subject who decides to answer "yes" when there is the slightest chance that he has seen the picture before. The two subjects may have the same memory accuracy but make different decisions as to how to respond. Swets, Tanner, & Birdsall (1961) explained that the detection task involves a problem in statistical decision. According to signal detection theory, the criteria that affect the decision factor can affect the subject's responses independent of actual memory strength (detection) for each stimulus. Although signal detection theory was developed in relation to a procedure involving actual detection of an auditory stimulus, the theory is quite adaptable to studies in visual memory. Keely (1971) discussed several studies concerning the position bias of young children and children with low intelligence in serial positions tasks. Keely used signal detection analysis (d' value) of the data to separate out the effects of position bias.

In his study, Ellis (1963) explained that meaningfulness or familiarity of materials might be a factor in short-term memory in individuals with low mental ability. Studies since that time have supported his hypothesis. O'Connor & Hermelin (1963) proposed repetition and high intensity level of stimulus as the suitable methodology for dealing with the learning problem of retarded children. The high intensity level of the stimuli could be what proved so meaningful to the subjects. Elliot (1970) believed meaningful material to be the key to why educable mentally retarded (EMR) children had retention equivalent to that of normal children. Vergason (1968) said that material is learned better by retardates if it is meaningful, but he had doubts as to whether it is retained better. However, if meaningful material is learned better, as Vergason said, it must be managed better in the short-term memory. And if material is adequately dealt with in the short-term memory then it will be transfered to the long-term memory and be retained. Ausubel (1967) also suggested that learned meaningful material is more resistant to forgetting.

The theory that meaningful materials are important in work with children with low intelligence has been used by many teachers and researchers. However, their definitions of "meaningful" vary. Elliot (1970) used "familiar" as synonomous with "meaningful." He substituted familiar proper nouns (local names and locations) for impersonal and unfamiliar proper nouns in a standard text. Henderson (1971) successfully used "direct experience" in the form of a variety of sensory experiences as meaningful material. For example, Henderson had EMR high school students experiment with various sounds, smells, and tactile sensations in a creative writing class. Ausubel (1967) defined meaningful material as that material which is relatable to already existing concepts. Brown &

Sellin (1967) defined meaningful activities as colorful pictures, recordings, discussions, slides, and creative activities. Montessori (1912) placed much emphasis upon sensory experiences. She had each child hold the three-dimensional color tablets and then slowly learn to recognize the colors visually. Montessori believed very strongly in this "education of the senses" and felt that the child could learn better when progressing from the concrete to the abstract. Although she did not use the word "meaningful" specifically, it is the concrete and manipulative nature of the Montessori materials that make them meaningful.

Scott & Scott (1968) stated that a poor short-term memory may provide only a limited buffer storage system and, thus, reduce the probability that a given piece of information will be permanently stored. Gagné (1970) elaborated on this idea and suggested that coding is the process that goes on in the buffer area of the short-term memory. In noting the greater size constancy induced by three-dimensional objects versus two-dimensional objects, Kubzansky, Rebelsky, & Dorman (1971) explained their findings on the basis of the fact that there are a greater number of cues present in the three-dimensional objects. While studying the perceptual development of infants, Fantz (1961) found that infants of one to six months had more visual interest in a solid sphere than in a flat circle of the same diameter. This experiment indicated that three-dimensional objects are perceived earlier, or at least more readily, than two-dimensional objects. Rohwer (1972) found greater response accuracy in a paired-associates task when three-dimensional objects were used to provide additional cues for memory. Hom (1967) encouraged the use of familiar cues to facilitate learning in mentally retarded children. Three-dimensional objects may, by means of their added cues, provide the meaningfulness that is necessary to aid in short-term memory of children with low intelligence.

In summary, Ellis (1963) and Hermelin & O'Connor (1964) stated that there is an inadequacy in the stimulus trace of subnormals. This stimulus trace inadequacy is in the primary memory and causes problems in acquisition of information (Belmont & Butterfield, 1969) or rehearsal strategies (Ellis, McCarver, & Ashurst, 1970). Once the task had been thoroughly learned Underwood (1954) and O'Connor & Hermelin (1963) found no differences in learning or memory scores between normals and retardates. An appropriate method for gathering memory data from children of low intelligence is the serial positions task developed by Atkinson, Hansen, & Bernbach (1964). Calfee (1970) and others found considerable position bias in children's response behavior. Murdock (1966) explained how signal detection theory could be used to analyze the results in a test of memory. Keely (1971) demonstrated the use of this analysis in dealing with the position bias of young children and children of low intelligence. Ellis (1963) theorized that meaningful material could be a key factor in short-term memory of children with low mental ability. Others have agreed with him but their definitions of meaningful vary. Elliot (1970) used familiar materials. Henderson (1971) and Montessori (1912) used sensory experiences. Gagné (1970) suggested that coding is the process that is lacking in the limited buffer area of the short-term memory. Fantz (1961) showed that infants have more visual interest in three-dimensional objects. Studies by Kubzansky, Rebelsky, & Dorman (1971) and Rohwer (1972) suggested that three-dimensional objects provide critical added cues.

The specific hypothesis is that three-dimensional objects in a serial positions task will yield greater short-term memory response accuracy than will two-dimensional objects in elementary school children with low intelligence.

II

METHOD

Subjects

Subjects were 14 students whose IQ scores ranged from 60 to 85 on the Otis-Lennon Test of Mental Maturity, the Wechsler Intelligence Scale for Children, or the Short Form Test of Academic Aptitude. Subjects were fourth, fifth, and sixth graders from regular classrooms at an elementary school in a middle income area in Albuquerque, New Mexico. The subjects were randomly assigned to two groups of seven each.

Instrumentation and Stimulus Materials

The two-dimensional objects were eight pictures of common items from a child's environment. The pictures were all in color and all had red backgrounds. The pictures, 2-3/4 by 2-3/4 inches in size, were backed with plain cardboard and laminated. They were from the book I Spy (Ogle & Thoburn, 1970). Objects pictured were a ball of string, a nail, a lemon, a band aid, an onion, a key, a button, and a paper clip. The three-dimensional objects were the same as those pictured on the cards. They were covered by four inch wooden cubes. There were duplicates of all of the objects that served as stimulus cues or probes.

Procedure

The first phase of the experiment was stimulus familiarization. The experimenter presented all of the stimulus items and named each one. The subject was then asked to name each stimulus item. The criterion of successful familiarization was that the subject could name each item within five seconds upon presentation.

One group of subjects was given the serial positions task with the two-dimensional objects (Condition A) first and two weeks later was given the task with the three-dimensional objects (Condition B). The other group was given Condition B first and Condition A two weeks later.

After the stimulus familiarization, the experimenter showed five of the stimulus objects to the subject for two seconds in succession. Each stimulus object was turned facedown (Condition A) or covered with a box (Condition B) and placed in a row from the subject's right to left after it had been shown to him. The experimenter held up the stimulus cue and said, "Show me the one that looks like this." The subject got a second choice if the first choice he uncovered was not correct. Only two choices were allowed on each trial. Each subject was run for 15 trials under each condition. Each of the five positions contained the correct response three times in each session. Each stimulus item appeared in the 15 trials nine or ten times and was correct one or two times. The assignment of stimulus items to positions was randomly determined for each trial. The arrangement of stimulus items and correct response position was different for each condition (Appendixes A and B).

Data Collection

The experimenter marked the subject's position choice on the record sheet (Appendix C) for each trial. In order to facilitate scoring, the correct response position was outlined with a dark line for each trial on the record sheet. The first answer was marked with a check (✓) in the proper place and, if there was a second answer, the second choice was marked with an X. The same procedure was followed for all 15 trials in both Condition A and Condition B.

Data Analysis

Because of the existence of position bias in subjects in a study of this type, a signal detection analysis was used to separate out effects of position bias from memory. Percent correct was calculated for every position for each subject. The <u>d'</u> value, based on percentage data, was calculated for every position for each subject. Mean percent correct was calculated for each subject and for each position. Mean <u>d'</u> values were also calculated. A correlated <u>t</u> test ($p < .05$) was performed on both raw data and the <u>d'</u> values.

III

RESULTS

The purpose of this study was to investigate the effects of three-dimensional stimuli versus two-dimensional stimuli in a serial positions task on the short-term memory of elementary school children with low intelligence. Table I shows the raw data on hits and false alarms by subject for both Condition A (pictures) and Condition B (objects). The hit score is the number of times, out of a possible three in this study, the subject chose the position and was correct. The false alarm score is the number of times, out of a possible twelve, the subject chose the position and was incorrect. Table 1 also shows the total number of responses per position. A correlated _t_ test on the raw scores was significant at the .01 level.

Table 2 shows the percent correct obtained in each individual position in both conditions. The percent correct on any position per subject ranges from 0 to 100 in both conditions. The mean percent correct for all five positions by subject ranges from 40 to 100 in Condition A. In Condition B the mean percent correct for all five positions by subject ranges from 47 to 100. The mean percent correct for each position ranges from 52 to 71 in Condition A. In Condition B the mean percent correct by position ranges from 67 to 86. In Condition A only one subject got 100 percent correct and two other subjects received 80 percent correct. However, under Condition B two subjects scored

TABLE 1

Hits (H) and False Alarms (FA)

Condition A (Pictures)

Subjects	1 H	1 FA	2 H	2 FA	3 H	3 FA	4 H	4 FA	5 H	5 FA
AC	3	0	3	0	3	0	3	0	3	0
GF	1	1	1	2	2	3	2	0	3	0
MK	1	1	2	1	2	2	1	3	2	0
GP	3	0	3	3	2	0	2	0	2	0
RK	2	1	3	3	1	0	1	1	2	1
MC	3	0	3	2	0	0	2	2	2	1
TC	1	1	2	2	1	3	0	3	2	0
RC	2	1	2	2	2	2	2	1	1	0
DK	2	1	2	3	0	0	1	3	3	0
PR	2	3	0	2	0	2	2	2	2	0
DC	3	0	3	1	2	0	2	1	2	1
RN	3	0	2	1	3	2	1	2	1	0
JC	3	2	3	0	2	2	2	0	2	0
DR	1	0	0	3	2	3	1	1	2	2
Total responses	41		54		41		41		34	

Condition B (Objects)

Subjects	1 H	1 FA	2 H	2 FA	3 H	3 FA	4 H	4 FA	5 H	5 FA
AC	3	0	3	0	3	0	3	0	3	0
GF	3	1	2	1	2	4	0	0	2	0
MK	0	0	2	5	1	2	2	1	2	0
GP	3	0	1	1	2	2	2	0	3	1
RK	2	0	2	3	1	1	1	3	2	0
MC	3	1	2	1	3	0	3	0	2	0
TC	2	1	1	1	2	2	2	1	3	0
RC	3	0	1	0	2	1	3	1	3	1
DK	3	0	2	1	3	1	2	0	3	0
PR	2	1	1	2	0	2	2	3	2	0
DC	3	0	3	0	3	0	3	0	3	0
RN	3	1	2	0	2	0	3	1	3	0
JC	3	1	3	0	2	0	3	1	2	0
DR	1	1	3	2	2	1	0	2	3	0
Total responses	41		45		44		42		38	

Note.—Item 5 was the most recent presented in all cases.

100 percent and five subjects scored 80 percent or better. Figure 1 shows the mean percent correct by position for both conditions. The configuration of the curve in Figure 1 indicates the classical serial position effects.

Table 3 shows the difference between the mean of Condition B as compared to the mean of Condition A based on percentage data. Two subjects received the same percentage scores on both conditions. Three subjects did better in Condition A than in Condition B. Nine subjects did better in Condition B than in Condition A. Six of these nine subjects improved 20 percent or more in Condition B as compared to Condition A.

Table 4 gives the d' values for both conditions by subject and by position. A signal detection analysis was used because of the existence of position effects in a study of this type. The d' value of signal detection analysis gives a more accurate memory score than percent correct. The d' value describes the relationship between the hit scores and the false alarm scores. In Condition A the d' value on individual positions ranged from -1.654 (zero hits and three false alarms) to 4.654 (three hits and zero false alarms). The d' value for individual positions in Condition B ranged from -1.373 (zero hits and two false alarms) to 4.654. The mean of the d' values for each position ranged from 1.473 to 2.750 in Condition A. The mean of the d' values for each position ranged from 2.192 to 3.714 in Condition B. In Condition A the mean of the d' values for all five positions by subject ranged from .506 to 4.654. The mean of the d' values for all five positions by subject ranged from .973 to 4.654 in Condition B. Figure 2 shows the mean d' value by position for both conditions.

TABLE 2

Percent Correct

Condition A (Pictures)

Subjects	Positions 1	2	3	4	5	$\overline{X}$
AC	100	100	100	100	100	100
GF	33	33	67	67	100	60
MK	33	67	67	33	67	53
GP	100	100	67	67	67	80
RK	67	100	33	33	67	60
MC	100	100	0	67	67	67
TC	33	67	33	0	67	40
RC	67	67	67	67	33	60
DK	67	67	0	33	100	53
PR	67	0	0	67	67	40
DC	100	100	67	67	67	80
RN	100	67	100	33	33	67
JC	100	67	67	67	67	73
DR	33	0	67	33	67	40
$\overline{X}$	71	67	53	52	69	62

Condition B (Objects)

Subjects	1	2	3	4	5	$\overline{X}$
AC	100	100	100	100	100	100
GF	100	67	67	0	67	60
MK	0	67	33	67	67	47
GP	100	33	67	67	100	73
RK	67	67	33	33	67	53
MC	100	67	100	100	67	87
TC	67	33	67	67	100	67
RC	100	33	67	100	100	80
DK	100	67	100	67	100	87
PR	67	33	0	67	67	47
DC	100	100	100	100	100	100
RN	100	67	67	100	100	87
JC	100	100	67	100	67	87
DR	33	100	67	0	100	60
$\overline{X}$	81	67	67	69	86	74

FIGURE 1

Mean Percent Correct by Position

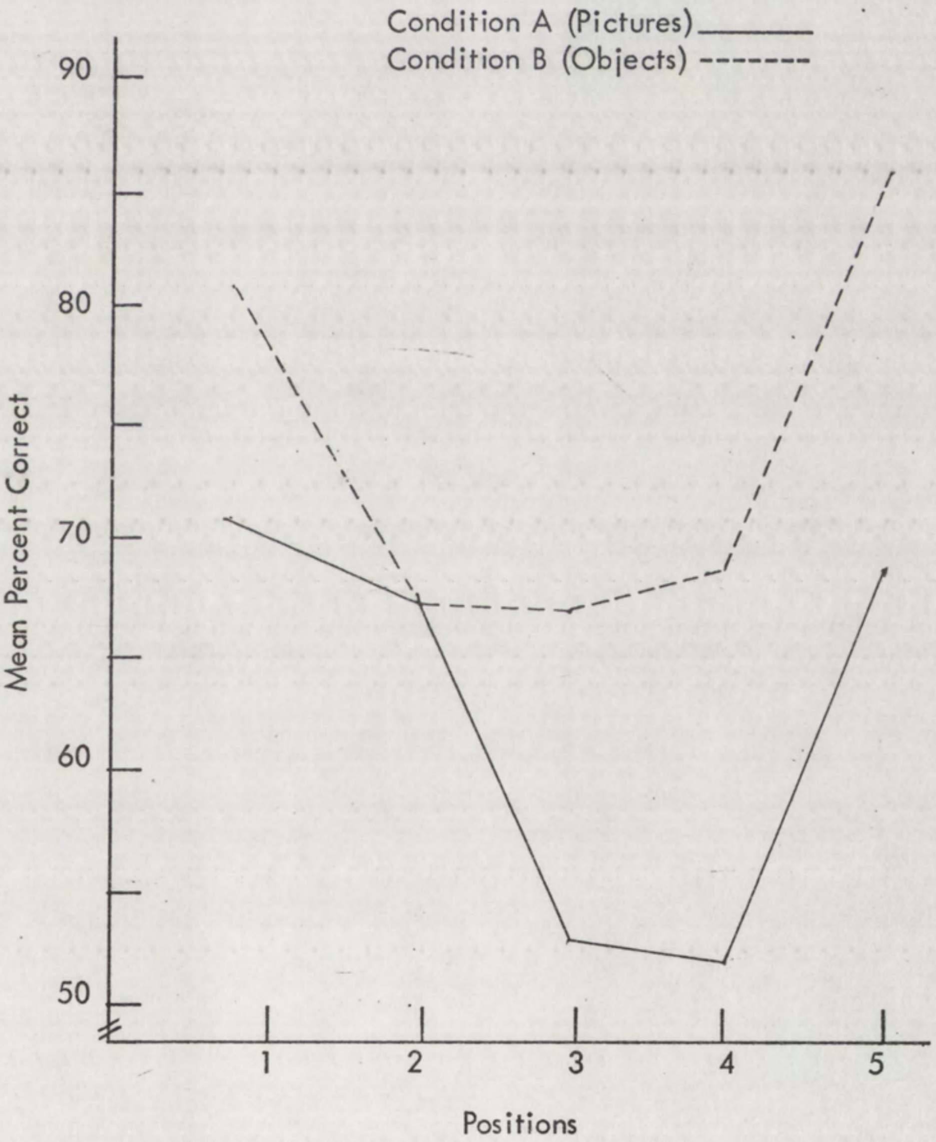

TABLE 3

The Difference Between the Mean of Condition B (Objects) and the Mean of Condition A (Pictures)

Subjects	Percent		
	B	A	Difference
AC	100	100	0
GF	60	60	0
MK	47	53	-6
GP	73	80	-7
RK	53	60	-7
MC	87	67	20
TC	67	40	27
RC	80	60	20
DK	87	53	34
PR	47	40	7
DC	100	80	20
RN	87	67	20
JC	87	73	14
DR	60	40	20

The classical serial position effects are also shown quite clearly in Figure 2.

Table 5 shows the difference between the mean d' values under Condition B as compared to Condition A. Subject AC received the same percentage score and the same mean d' score in both conditions. Subject GF received the same percentage score in both conditions but did not receive the same mean d' value because the distribution of hits and false alarms differed in the two conditions. Subject GF's mean d' value was higher in Condition A than in Condition B. Three other subjects had higher mean d' values in Condition A than in Condition B. Nine subjects received higher mean d' scores in Condition B than in Condition A. A correlated t test on the d' values was significant on the .01 level.

TABLE 4

d' Values

Condition A (Pictures)

Subjects	Positions					
	1	2	3	4	5	$\overline{X}$
AC	4.654	4.654	4.654	4.654	4.654	4.654
GF	.965	.514	1.114	2.767	4.654	2.003
MK	.965	1.845	1.394	.231	2.767	1.440
GP	4.654	3.001	2.767	2.767	2.767	3.191
RK	1.845	3.001	1.887	.965	1.845	1.909
MC	4.654	3.281	0	1.394	1.845	2.235
TC	.965	1.394	.234	-1.653	2.767	.741
RC	1.845	1.394	1.394	1.845	1.887	1.673
DK	1.845	1.114	0	.234	4.654	1.569
PR	1.114	-1.373	-1.373	1.394	2.767	.506
DC	4.654	3.732	2.767	1.845	1.845	2.969
RN	4.654	1.845	3.281	.514	1.887	2.436
JC	3.281	2.767	1.394	2.767	2.767	2.595
DR	1.887	-1.653	1.114	.965	1.394	.741
$\overline{X}$	2.713	1.823	1.473	1.478	2.750	2.047

Condition B (Objects)

AC	4.654	4.654	4.654	4.654	4.654	4.654
GF	3.732	1.845	.880	0	2.767	1.845
MK	0	.642	.514	1.845	2.767	1.154
GP	4.654	.965	1.394	2.767	3.732	2.703
RK	2.767	1.114	.965	.234	2.767	1.569
MC	3.732	1.845	4.654	4.654	2.767	3.530
TC	1.845	.965	1.394	1.845	4.654	2.141
RC	4.654	1.887	1.845	3.732	3.732	3.170
DK	4.654	1.845	3.732	2.767	4.654	3.530
PR	1.845	.514	-1.373	1.114	2.767	.973
DC	4.654	4.654	4.654	4.654	4.654	4.654
RN	3.732	2.767	2.767	3.732	4.654	3.530
JC	3.732	4.654	2.767	3.732	2.767	3.530
DR	.965	3.281	1.845	-1.373	4.654	1.874
$\overline{X}$	3.259	2.259	2.192	2.454	3.714	2.776

FIGURE 2

Mean d' Value by Position

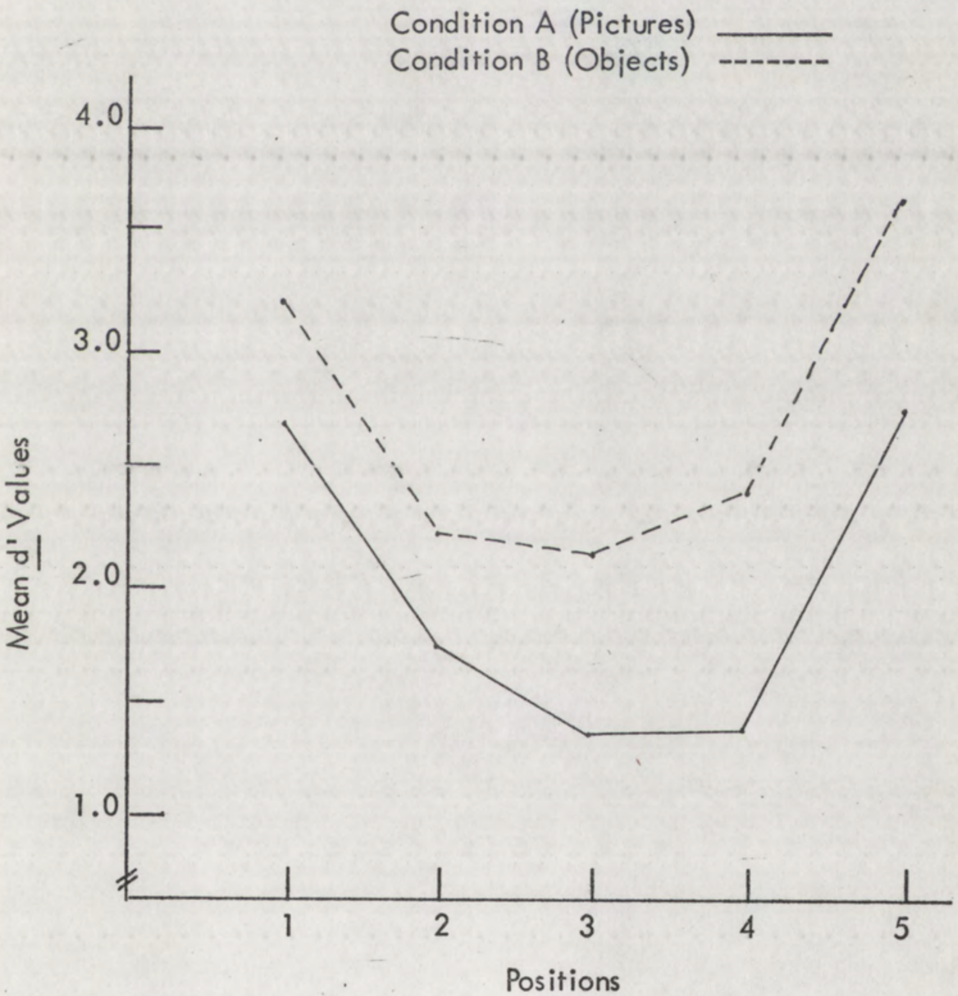

TABLE 5

The Difference Between the d' Mean of Condition B (Objects) and the d' Mean of Condition A (Pictures)

Subjects	d' Mean		
	B	A	Difference
AC	4.654	4.654	0
GF	1.845	2.003	-.158
MK	1.154	1.440	-.286
GP	2.703	3.191	-.488
RK	1.569	1.909	-.340
MC	3.530	2.235	1.295
TC	2.141	.741	1.400
RC	3.170	1.673	1.497
DK	3.530	1.569	1.961
PR	.973	.506	.467
DC	4.654	2.969	1.685
RN	3.530	2.436	1.094
JC	3.530	2.595	.935
DR	1.874	.741	1.133

IV

DISCUSSION

The specific hypothesis of this study was that elementary school children with low intelligence would have greater short-term memory response accuracy on a serial positions task with three-dimensional objects than with two-dimensional objects. Correlated _t_ tests on the percent correct and the _d'_ data were significant at the .01 level.

The significant results of this study are similar to the results of a study by Rohwer (1972) in which three and five year old subjects did better on a paired-associates task when the paired-associates were represented by three-dimensional objects than when represented by pictures. Better memory performance with three-dimensional objects suggests that children with low intelligence, as in this study, or very young children, as in Rohwer's study, learn better with additional cues. Ellis, McCarver, & Ashurst (1970) said that meaningful material had no effect on the memory performance of retarded children. But the meaningful materials in that study were pictures of common objects as opposed to pictures of nonsense shapes. Perhaps three-dimensional objects with their additional cues would have been more meaningful and resulted in better memory performance in Ellis, McCarver, & Ashurst's study.

The experimenter observed rehearsal strategies in the subjects. The rehearsal was most obvious at the beginning of each trial. Subjects tended to say the names of the objects in positions one and two in soft voices or to move their lips. It is possible that more meaningful materials, in this case three-dimensional materials, stimulate rehearsal. Rehearsal may have been related to the high level of performance on the first position. Both the percent correct data and the <u>d'</u> data indicate a definite primacy effect. Ellis, McCarver, & Ashurst (1970) found no evidence of a primacy effect in a serial positions task with retarded children, although a primacy effect was in evidence in children with low intelligence. Atkinson, Hansen, & Bernbach (1964) also found no evidence of a primacy effect in very young children. However, when the data from Atkinson, Hansen, & Bernbach's study were reexamined (Donaldson & Strang, 1969) with position bias taken into account, a primacy effect was found.

Due to the lack of apparent rehearsal on the last position, it seems that rehearsal is not the explanation for the recency effect. Subjects did best on the most recent position. As in a study by Donaldson & Strang (1969), subjects had the highest percent of correct choices and the lowest percent of errors on the most recent position (position five). Calfee (1970) also found both primacy and recency effects when position bias was taken into account.

Other position effects were observed in this study. Subjects did poorly on the middle position (position three). Based on percentage data, subjects did worst on position three in Condition B. The percent correct scores on both position three and position two were 67 in Condition B. In Condition A subjects did worse on position four than on position three by one percent.

The d' values, however, do indicate that subjects did worse on position three overall. According to Ellis & Munger (1966) there is a strong tendency for subjects in a study of this type to respond to the middle position, whether that position is correct or incorrect. Subjects in this study tended to respond most often to position two and second most often to the middle position.

The percent correct data appear to show that subjects did quite well on position two. However, the marked drop in the d' value for position two shows that the subjects got position two correct as often as they did simply because they chose position two more frequently. There was not as much of a position bias for position two in Condition B as in Condition A. Another observation concerning position two was that subjects seemed to get position two and position four confused. Subjects often reached for position two and decided to choose position four or reached for position four and finally chose position two. Perhaps an increase in the number of positions would eliminate the apparent confusion between positions two and four.

Another minor change in the procedure might have lead to a greater difference between performance in Condition B as compared to Condition A. The mean percent correct in Condition A was 62 and the mean percent correct in Condition B was 74. While these percents do not indicate a ceiling effect, it is possible that the high level of performance could have prevented a larger difference between the two conditions. An example of this high level of performance is the scores on position five in Condition B. Eight subjects received scores of 100 percent correct on position five in Condition B and the six other subjects made only one error apiece or 67 percent correct. Such a high level of performance indicates that the subjects might have done even better had there been either more trials per session or more positions per trial.

Such flaws in procedure are due to this specific study and are outweighed by the value of the serial positions task. The serial positions task is an excellent research tool for testing the short-term memory of children with low intelligence. Although Donaldson & Strang (1969) found their subjects lost interest in the task, a high level of interest was maintained in the subjects in the present study, as was also reported in the serial positions study done by Atkinson, Hansen, & Bernbach (1964). The subjects seemed to enjoy both sessions and their lack of anxiety over the task probably made the results more accurate. The use of the signal detection analysis and the d' value greatly increase the amount of information that can be obtained from a test of short-term memory. Signal detection analysis makes possible the identification of position bias and provides a more accurate measure of memory strength which is not possible with a traditional analysis based solely on percent correct.

In addition to implications for research on short-term memory, the present study also has some classroom implications. Teachers of children with low intelligence, in regular and special classrooms, make considerable use of visual aids in the form of pictures. Teachers also use three-dimensional materials to involve senses other than the visual sense in learning. The children manipulate these objects in order to learn through other senses. But in this study the children had better memory scores with the three-dimensional objects without tasting, smelling, hearing, or even touching the objects. The present study does not deal with the manipulative nature of three-dimensional materials. This study does indicate that three-dimensional materials may be valuable in the classroom without even being manipulated.

The conclusions that can be drawn from the present study are limited by the small number of subjects. However, the significance of the correlated _t_ tests suggests that a similar study with a larger number of subjects is in order. A similar study also needs to be undertaken with a group of subjects who are retarded. Any research that could lead to new information on how retarded children learn and how they might learn better would be of great value to educators. A similar study could be initiated with children with other learning handicaps to show the effects of three-dimensional objects on their short-term memory.

In summary, the hypothesis that three-dimensional objects in a serial positions task would yield greater short-term memory response accuracy than would two-dimensional objects in elementary school children with low intelligence was supported. A correlated _t_ test on the percent correct data was significant at the .01 level. Signal detection analysis was performed because the _d'_ value gives a more accurate measure of memory strength. A correlated _t_ test on the _d'_ value was also significant at the .01 level. The classical serial position effects of primacy, recency, and a poor performance on the middle position were demonstrated. The serial positions task appears to be most appropriate for testing the short-term memory of children with low intelligence and the _d'_ value is most useful in analyzing the data. Studies using a serial positions task with three-dimensional objects would also be of value with more subjects, retarded subjects, and with children with other learning handicaps.

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APPENDIXES

APPENDIX A

Arrangement of Stimulus Items in Response Positions:
Condition A (Pictures)

Trials	Positions					
	1	2	3	4	5	Correct position
1	button	string	lemon	nail	onion	2
2	key	band aid	onion	string	paper clip	5
3	nail	paper clip	band aid	button	string	1
4	onion	string	key	paper clip	button	3
5	button	onion	lemon	nail	key	1
6	band aid	key	paper clip	lemon	string	5
7	key	paper clip	nail	button	band aid	1
8	button	band aid	onion	paper clip	lemon	4
9	band aid	string	lemon	nail	key	3
10	string	onion	paper clip	key	button	5
11	paper clip	lemon	key	onion	string	4
12	nail	string	band aid	lemon	key	3
13	string	nail	lemon	button	band aid	2
14	key	button	onion	band aid	nail	4
15	paper clip	onion	nail	lemon	button	2

APPENDIX B

Arrangement of Stimulus Items in Response Positions:
Condition B (Objects)

Trials	Positions					
	1	2	3	4	5	Correct position
1	string	band aid	nail	paper clip	key	5
2	button	lemon	paper clip	key	onion	2
3	key	nail	onion	band aid	lemon	3
4	lemon	onion	button	paper clip	string	1
5	nail	lemon	band aid	button	onion	5
6	button	nail	string	key	paper clip	1
7	string	paper clip	button	lemon	band aid	2
8	key	lemon	band aid	string	onion	3
9	onion	key	button	band aid	paper clip	5
10	button	string	paper clip	nail	band aid	4
11	key	band aid	string	paper clip	button	3
12	nail	paper clip	lemon	key	onion	4
13	button	key	paper clip	nail	string	1
14	onion	string	nail	button	lemon	2
15	nail	lemon	string	band aid	onion	4

APPENDIX C

Record Sheet

Subject ____________________ Condition ____________

Trials Serial Positions

	1	2	3	4	5	correct 1	correct 2
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							