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ABSTRACT

Evaluated with two age groups (mean age 8.1 years or 10.6 years) totaling 22 learning disabled children was whether there is an age related increase in recognition for visual nonverbal short term memory (STM) and the effects on STM of stimulus dimensionality, primacy, recency, and second choice responses. A serial recognition task was used to compare performance of the two age groups with two and three dimensional representations of nonverbal eight-point random shapes. Recognition of both dimensions was significantly better by older than younger children. No significant differences were found for either age group between two or three dimensional stimuli or in response strategies of first and second choices; but it was found that the three dimensional representations were recognized significatly better at the first serial position. Among significant departures from findings on verbal STM performance studies was that second choices were usually incorrect if the first choices were incorrect suggesting that similar mediational inefficiencies occurred. (Author/DB)

Nonverbal Visual Short-Term Memory as a Function of Age and Dimensionality in Learning Disabled Children

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Nonverbal Visual Short-Term Memory as a Function of Age and Dimensionality in Learning Disabled Children

The purpose of this study was to determine whether an age-related increase in recognition for visual nonverbal short-term memory (STM) occurred in learning disabled children. Also under investigation was the effect of stimulus dimensionality, primacy, recency and second choice responses on a nonverbal serial recognition task.

A number of recent STM theorists (Adams, 1967; Neisser, 1967; Posner, 1973) have suggested the necessity for gathering more information about the recall of nonverbal visual stimuli. Posner (1967) and others (Haith, Morrison, Sheingold & Mindez, 1970; Jones, 1973; Morrison, Holmes & Haith, 1974) have suggested that nonverbal information is a more direct study of visual STM than the analysis of linguistic representation associated with the visual events. Haith (1971), Murray and Newman (1973), and Pavio (1970) have suggested that verbal encoding is not a necessary process for STM of visual input. The development of nonverbal visual STM has not been studied extensively (Cherry, 1970; Nelson, Brooks & Borden, 1973). To the author's knowledge, no experimental studied of the developmental aspects of nonverbal STM with learning disabled children have been done. However, several investigators (e.g., Chalfant & Flathouse, 1971; Heriot, 1974; Kirk, 1973; Koppitz, 1973; Senf & Seymour, 1970; Symmes, 1972) have suggested that learning disabled children do not follow normal STM developmental patterns.

The mediation deficiency hypothesis states that there is a stage in development during which verbal responses are present but do not serve as mediators (Flavell, Friedrichs & Hoyt, 1970; Flavell, 1970; Keeney, Cannizzo & Flavell, 1967; Reese, 1962). This hypothesis has been used in studies by Corsini, Pick and Flavell (1968) and others (Daehler, Horowitz, Wynns & Flavell, 1969; Ryan, Hegion & Flavell, 1970) to explain differential age effects with nonverbal mediation on a STM memory task with normal children. Corsini et al. (1968) found in a study using nonverbal material that there is an increasing availability of certain already acquired skills in age-related recognition. The increasing availability of a nonverbal mediator was suggested as being age-related. Further, Posner (1967) and others (Corsini et al., 1968; Morrison et al., 1974) suggested that visual STM deficits found in children are not just related to verbal rehearsal, but to visual coding.

Ross and Youniss (1969) found that recall of the sequence of nonverbal items was more difficult for younger than older children. Results from this experiment indicated that the tendency for a primacy condition is strong for children as young as five years, however, this tendency is weakened or erased by the introduction of other variables such as nonverbal forms. Unfamiliar nonverbal material is uniformly more difficult than familiar material for recognition accuracy and serial position order (Bernbach, 1967; Keely, 1971; Neimark, Slotnik, & Ulrich, 1971). In a study by Atkinson, Hansen and Bernbach (1964) using a serial recognition task, recency effects were found for young children, however, there was no evidence for a primacy effect. A later reanalysis by Keely (1971) of the data found by Atkinson et al. (1964), along with other findings which also did not yield primacy effects (Calfee, Hetherington & Waltzer, 1966; Donaldson & Strang, 1969), found the presence of a primacy effect by the use of a statistical measure adapted from signal detection theory. Reanalysis by use of this measure indicated that while primacy effect increased with age, it was not absent even at the youngest age. The studies of Atkinson et al. (1964), Calfee (1969), Ellis and Munger (1966), and Hansen (1965) with normal children have also presented evidence that STM is not "all-or-none", or restated, that second guesses following an error tend to be correct more often than would be predicted by chance. Studies using familiar material (items that subjects can label) have found response biases for choosing the middle serial positions (Atkinson et al., 1964; Calfee, 1969; 1970; Ellis & Munger, 1966).

Little is known about stimulus saliency on nonverbal memory serial position effects. Piaget and Inhelder (1956) and Gibson (1969) have discussed the importance of three dimensional stimuli for fostering cognitive development. The use of three dimensional objects has been considered fundamental to educational classrooms for instructional purposes (Berlyne, 1963; Bloom, Davis & Hess, 1965; Hunt, 1961; Vygotsky, 1962). It has been theorized that three-dimensional objects help develop correct perceptions for learning disabled children which facilitate recognition (Cruickshank, 1965;

Roach & Kephart, 1966; Symmes, 1972). There has been very little investigation comparing recognition of three dimensional objects with their two dimensional representations (Iscoe & Semler, 1964; Devor & Stern, 1970). Studies that have found a recognition superiority for objects compared with pictures (Iscoe & Semler, 1964; Maechtlen & Birch, 1974) have been explained in terms of Gibson's (1969) theory of "redundant information"(stimulus salience). Previous investigations have involved specifically the use of familiar material.

The present experiment investigated the effects of age and dimensionality on performance of learning disabled children on a nonverbal serial recognition task. Analogies were made to verbal serial recognition response patterns in an attempt to determine similarities between verbal and nonverbal patterns. Dimensional salience effects on age and serial position were considered. Salience was based on the degree to which a two or three dimensional item was correctly recognized by the subject. Specific hypotheses for the study were that (I) Older learning disabled children would perform significantly better on both two and three dimensional tasks than the younger learning disabled children; (II) Three dimensional recognition would be significantly better than two dimensional for both age groups; (III) A primacy and recency effect would be found in both age and treatment groups; and (IV) Second choice responses following an error on first choices would be correct more often than chance with both age and treatment groups.

Method

Experimental Design

The experimental design of this study is represented factorally as a 2 x 2 x 6 analysis of variance. This design was a split-plot design, with one between-block treatment (age) and two within-block treatments (dimensionality and serial positions). The sequence of administration of the within-block treatment was randomized independently for each group of subjects, requiring a repeated measures analysis.

Subjects

Learning disabled children in two age groups of 11 each, matched on IQ and sex, served as subjects in the experiment. Children were selected from a special education class (Resource Room) in the Albuquerque Public School District. The school was located in a middle class neighborhood. Group I had a mean chronological age (CA) of 8.1 and standard deviation (SD) of .26. The mean WISC Full Scale IQ for Group I was 93.68, with a SD of 12.34. Group II had a mean CA of 10.6 and a SD of .10. The mean WISC Full Scale IQ score for Group II was 94.14, with a SD of 11.67. Classification of the learning disabled children was based upon the New Mexico State Standards and the Appraisal and Review Committee in the Albuquerque public schools which define a learning disabled student as "one who exhibits one or more deficits in the essential learning process requiring Special Education, which may be characterized by various combinations of deficits in perception, conceptualization, language, memory, control and attention, impulse or motor function."

None of the children in this experiment were on medication. All children in both groups were randomly assigned for participation in the two treatment conditions. Five of the children in each group received the two dimensional treatment first and the remainder received the three dimensional treatment first. All subjects participated in both treatment groups with a two-week time interval between the sessions. Order effects were not found in the treatment conditions.

Stimuli

The stimuli were six nonsense random shapes selected from Vanderplas and Garvin's (1959) eight-point assortment. These shapes (Numbers 19, 20, 22, 24, 25, 26) were chosen because of their low "association" and "content" values as established by Vanderplas and Garvin's (1959) norms. These figures were of lower association value than Ross and Youniss's (1969) nonverbal item classification. Each of the shapes used was drawn in black ink on a 10 x 10 cm white card with the same dimensions as the normed shapes. Also, a three dimensional representation of each random shape was constructed out of black styrofoam. Both pictures and objects were made in duplicate. The objects and pictures were of the same dimension, color, and surface texture. The depth of the three dimensional representation was 4.5 cm. Wooden boxes 10 cm square were used to cover the three dimensional objects in the serial recognition task after they had been presented.

Procedure

A serial recognition task procedure, similar to that used in other studies (Atkinson et al., 1964; Bernbach, 1967; Calfee, 1970; Calfee et al., 1966; Ellis & Munger, 1966; Hansen, 1965; Keely, 1971) was used in this investigation. The main difference in this investigation was that coded unfamiliar items were used and no pretest was given to determine labels. The absence of a pretest was based on the idea that pretesting children to determine spontaneous labels would provide a set for verbal mediations, even though the verbal codability of the items would be low for both groups (Robinson & London, 1971). Some investigations (Ellis & Muller, 1964) have found little effect for label pretraining in recognition tasks for six-point shapes, whereas others (Daniel & Ellis, 1972; Santa & Rankin, 1972) found that labeling facilitated recognition performance for more complex shapes. Although it may be impossible to completely prevent children from developing verbal codes for visual stimuli, it is possible to reduce the effectiveness by using items of the same class membership, such as eight-point shapes (Golstein & Chance, 1970) and controlling for prior pre-labeling (Ellis & Muller, 1964; Santa & Rankin, 1972).

Individual children were first shown all of the items at one time for two seconds. This was done to give the child a rough approximation of the shape of the stimuli and to protect him from being overwhelmed when the rate of information input exceeded his capacity for information processing, thus causing a low hit rate in the early trials (Bernbach, 1967; Calfee, 1970; Keely, 1971).

The cards or objects were collected immediately after this initial presentation. Following this, the child was presented with a series of six items (two or three dimensional) shown one at a time. Each item was exposed for two seconds. Children were not allowed to touch items. The two dimensional pictures were put in a face down array after exposure and the three dimensional objects were covered when not being shown. Once the array had been presented, a duplicate item (probe) was then shown and the subject was asked to point out the corresponding item in the presentation series.

Fifteen trials were presented in each session. Each trial consisted of six stimuli selected randomly for each serial position with the stipulation that each position would be correct no less than two times or more than three, and no item would be correct more than twice or less than once over the fifteen trials. In reference to randomizing items, a study by Eisenman and Jones (1968) found that association value or complexity of shapes did not vary when the shapes were presented in random or non-random array. However, randomization was necessary to control for item to position bias. If the first choice of the subject was incorrect, the subject was than given a second choice. The stimulus was presented from the child's right to left so that spatial and presentation positions were confounded (Ellis & Munger, 1966).

After the last trial presentation, children were asked how they remembered the items. All content and association responses were recorded as was done in Vanderplas and Garvin's (1959) study. Since the children participated in both treatment groups, each session was separated by a two week interval. The length of each session was 30 minutes.

Statistical Analysis

Recent studies (Banks, 1970; Keely, 1971; Murdock, 1966; Norman, 1966) have discussed and applied signal detection theory to the study of short-term memory. According to signal detection theory, two values may be obtained to estimate memory strength: a discrimination index and response bias. The discrimination index (d') can be calculated from the hit rate and false alarm rate (see Table 1 of Hochhaus, 1972, for raw data conversion). The hit rate was defined in this experiment as the proportion of correct serial positions that were recognized by the subject; the false alarm rate was the proportion of times a serial position was identified when the item was not actually presented. The C_j index was used as a measure of response bias (Banks, 1970). The C_j index was determined from the z score of the false alarm rate.

Results

Age and Dimensionality

The d' values were calculated at each serial position under both dimensionality conditions for each child's performance. A 2 x 2 x 6 repeated analysis of variance was performed on these scores. The mean d' values were calculated and are illustrated in Figure 1.

Insert Figure 1 about here

Significant main effects were found for age levels, F (1, 20) = 6.079, $p < .05$. Figure 1 shows that the age d' differences are the result of better performance by older children than younger children in both two and three dimensional conditions. Performance also improved significantly with age over most serial positions.

The nature of the stimulus, whether two or three dimensional, did not significantly affect overall performance in either age group, F (1, 20) = .683, $p > .05$. There was no significant interaction between dimensionality and age, which indicated that the salience of two or three dimensional representations did not change with these ages. The dimensionality by serial position interaction was not significant. There was no significant interaction between age, serial position, and dimensionality.

Serial Position

Significant main effects were found for serial positions, F (5, 100) = 3.482, $p < .01$. A comparison of primacy and recency performance is found in Figure 2. Primacy is defined as the average

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Insert Figure 2 about here

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d' score at the first serial position and recency performance as the average d' score for the last serial position. As shown in Figure 2, recency recognition performance was better than the recognition performance for the primacy position. A comparison of primacy and recency performance between the two age groups in the three dimensional treatment indicated significantly better serial recognition for Group II in both the primacy, t (100) = 24.49, $p < .001$, and recency, t (100) = 32.19, $p < .001$, positions.

A most unusual finding of this data is the lack of a primacy effect in the two dimensional condition of both age groups. In the two dimensional treatment, recognition for Group II was significantly better at the recency position, t (100) = 32.94, $p < .001$, but not at the primacy position. Serial recognition scores were higher for Group II than for Group I in the two dimensional primacy position but the difference was not significant. Overall, a substantial age-related development was found in the primacy and recency positions for both dimensionality treatments.

Response Bias

The C_j index (Banks, 1970), a measure of response bias, was used to obtain more direct evidence regarding differences in criterion levels over serial positions. This value was obtained from z scores of the false alarm rate. In Table 1, the lower score represents the greater bias for selecting a particular serial

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Insert Table 1 about here

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position. As shown in this table, the greatest response bias for both age groups in the three dimensional condition was in serial positions 3 and 4. The three dimensional treatment also indicated a similar group response strategy for positions 2 and 5. The older subjects had a greater preference for the primacy position, although both age groups had a bias for the middle positions.

All-or-None Learning

The question of all-or-none learning effect upon the learning disabled children was considered in second choice responses. In Figure 3 an a posteriori probability measure (see Table 3 of Calfee, 1969, for calculation) was used to determine memory strength of the

Insert Figure 3 about here

second choice response. A posteriori probability was defined as the likelihood that a subject is correct when he selects a serial position. This measure provides a relatively unbiased measure of memory strength (Calfee, 1969, 1970; Donaldson & Strang, 1969). As several investigators (Banks, 1970; Calfee, 1969; Maechtlen & Berch, 1974; Murdock, 1966) have indicated, the commonly used a priori functions, or proportion of times that a serial position is correctly chosen, are sensitive to both memory strength and response strategies. A subject may increase a priori second choice by selecting a particular position more often than he is certain. Data in Figure 3 indicated that all second choice responses, except Group II recognition on three dimensional serial position 1, were of less than chance performance for each serial position. More correct second choice responses were found, however, for the primacy performance (both first and second serial positions) in both age groups on the three dimensional treatment. When subjects were incorrect on the first choice responses for the last serial position (recency effect), a second choice was of little benefit.

Association and Content Values

Subjects in the experiment could not be identified as verbal rehearsers utilizing the approach of Flavell, Beach, and Chinsky (1966), Keeney et al. (19670, and Nelson et al. (1973). Direct observations of subjects indicated only one subject giving overt verbalizations. At the end of the 15 trials, subjects were assessed as being verbal rehearsers if they could provide association or content responses to three items. Again, only one older subject met this criteria. Analysis of his performance indicated a primacy score two standard deviations below the total group mean score. This was probably an attempt on the subject's part to utilize a verbal process in remembering the first and second positions. In the absence of any immediate labels, subjects would be required to select concepts to which the shape could be related. This would require more time on the part of a given subject and would probably result in an inferior performance by a subject who had utilized labels. All other scores of the subject were within mean range, possibly indicating a switch in mediating processes.

Association and content values for the total group are given for each item in Table 2. The association value (A) was the

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Insert Table 2 about here

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percentage of subject responding to the shape with the word "yes." The content value (C) was the total percentage of labels or words associated with the shapes. As shown in Table 2, even with a small number in each group, association responses were comparable to Vanderplas and Garvin's (1959) norms. More associations were made by older subjects. The content responses for both groups were lower than the 1959 norms. Also, content responses were similar for both age and treatment groups.

A test can be made of verbal mediation (Clark, 1965; Price & Slive, 1970) by requiring subjects to make covert responses overt during recognition performance. The present results suggested that the items were not implicitly labeled (content response) and, therefore, a nonverbal mediation system was functioning as a memory code independent of verbal representation.

Discussion

Hypothesis I predicted that older learning disabled children would perform significantly better on both two and three-dimensional nonverbal STM recognition tasks than the younger learning disabled children. One of the most obvious findings of the preceding experiment is the age-related increase in nonverbal serial recognition STM performance. Older learning disabled children performed significantly better on both the two and three dimensional tasks than the younger children, as predicted in the original hypothesis. This finding with learning disabled children is consistent with other findings using normal learning children (Corsini et al., 1968; Daehler et al, 1969; and Ryan et al, 1970) in which an age-related increase was found for normal children on a nonverbal STM task. Considering other nonverbal STM findings (e.g., Corsini et al., 1968), learning disabled children and normal learning children follow similar developmental patterns in nonverbal STM memory. Thus, it appears that overall an improvement is more a result of increasing use of nonverbal mediation with age rather than the absence of nonverbal mediation. The concept of mediation refers to some intermediate variable which is involved in storing and retrieving input (Flavell, 1970).

Hypothesis II predicted that three dimensional recognition would be significantly better than two dimensional recognition for both age groups. This hypothesis was not supported. The nature of the stimulus, whether two or three dimensional, did not have an overall significant effect on the recognition performances in either age group. Perhaps saliency (Gibson, 1969) is related to STM performance as found in studies by Maechtlen and Berch (1974) and Iscoe and Semler (1964). However, the relationship is unclear because, when using stimuli that are highly familiar, it is difficult, if not impossible, to discern whether it is the three dimensional representation or the verbal label which provides the redundant cue leading to better recognition performance. If labeling is the significant cue, this would conflict with Gibson's (1969) differentiation theory in which it is suggested that stimuli do not become enriched by learning verbal associations, but by the stimulus environment. Further, as found by Siegal and Allik (1973), highly familiar material with no control for labeling or association responses changes a visual STM experiment to a visual-auditory task, thus confounding a clear interpretation of either the effects of labels or visual stimuli. Controlling for verbal mediation in this study indicated that three dimensional cues did not provide a redundancy of information in serial recognition tasks; however, significant differences were found in the first and last serial positions.

Hypothesis III proposed a primacy and recency effect for both conditions. This hypothesis was supported except for the absence of a primacy effect in the two dimensional treatment. The lack of primacy in the two dimensional presentation for both age groups ostensibly gives support to the findings of Glanzer and Dolinsky (1965) and Ellis (1970) which indicated that verbal rehearsal plays its most important role in primacy performance. The lack of verbal mediators could account for the lack of primacy effect. Keely's (1971) use of the d' measure did reveal consistent primacy effects in the earlier studies (Atkinson et al., 1964; Calfee et al., 1966; Donaldson & Strang, 1969) in which no effect was found initially with verbal material. The d' measure in this study did not yield a primacy effect in the two dimensional treatment. The first serial position in the two dimensional treatment also did not yield any significant developmental improvement.

Possibly the lack of age-related effects in the two dimensional condition in this study was due to subjects being unable to rehearse the stimulus presentation effectively, due to overloading of their information processing capacities (Miller, 1956). If this was true, subjects would have to maintain attention to one position or a selected section of the serial position presentation to compensate for overloading of information processing capacities. The results of this study indicated, however, that no marked bias for any one position could account for the lack of primacy effect in the two conditions.

The findings of Posner (1973) and Morrison et al. (1970) are relevant to the results obtained. Since no verbal rehearsal was used, as indicated by the lack of primacy effect (Ellis, 1970; Glanzer & Dolinsky, 1965), the subjects' poor performance may have been due to an inability to attach a visual code or to visually rehearse the first serial position. The three dimensional treatment did yield a primacy effect, indicating that a redundancy of visual information was necessary in order to provide more cues to facilitate visual rehearsal. The results of Nelson et al. (1973) did suggest that the nonverbal memory system can function effectively in the coding of sequential information. The results of the present experiment suggested the possibility of a nonverbal visual rehearsal strategy at primacy position on the three dimensional treatment. Therefore, this stimulus enrichment (e.g., Gibson, 1969) provides the subject with additional stimulus information.

Primacy effects in the three dimensional treatment and recency in both treatments increased with age. This also is similar to findings using verbal material (Bernbach, 1967; Flavell, 1970; Flavell et al., 1970). Older learning disabled children's recognition performance was better than the younger children's at all the middle positions except serial position 2. Serial position response patterns (subjects' response biases) were similar for both age and treatment groups. Keely (1971), Bernbach (1967), and Hansen (1965) also found the order of task difficulty remained the same for all ages with a hard-to-label task. Biased responses for the middle positions were found, which is consistent with other studies (Atkinson et al., 1964; Calfee, 1969, 1970; Ellis & Munger, 1966) where children could label stimulus items.

In contrast to studies by Atkinson et al. (1964), Calfee (1969), Ellis and Munger (1966), and Hansen (1965), second guesses following an error were not correct more often than chance with nonverbal material. Consequently, hypothesis IV was not supported. The notion that recall of nonverbal information is "all-or-none" has not been reported in literature to date. Corsini et al. (1968) did find instances where subjects had failed to make a correct nonverbal representation of the stimulus. Ryan et al. (1970), in a study with normal subjects using a nonverbal task, found a small occurrence of "mediation inefficiencies." In the present experiment, mediation production was not an all-or-nothing occurrence. However, obviously production inefficiencies did occur. Older subjects' second choice responses were recalled correctly more often than younger subjects' (except for serial position 4), although, as already stated, second choice correct responses for both age groups were less than chance. Both learning disability age groups in the present study appear to be subject to mediational inefficiencies.

The content responses of all subjects were lower than previous experimental classifications of nonverbal material (Goldstein & Chance, 1970; Ross & Youniss, 1969; Vanderplas & Garvin, 1959). The present results suggested that nonverbal memory can function effectively in a STM task similar to response patterns in verbal studies.

There was no appreciable difference between dimensional codability values (association and content) in either learning disability age group. If verbal mediation was an important factor in this STM task, then a relationship should exist between the number of correct recognition of the stimuli and their recall. The analysis indicated that subjects' responses were invariant to such a degree that it caused one to question whether spontaneous verbal labels, such as those used by the learning disabled children, can be helpful in facilitating STM performance on this type of task. This interpretation is consistent with Santa and Rankin's (1972) study which suggested that, if language codability is low for items, labeling does not provide information about the image. Considered along with other findings (Palermo, 1970; Pavio, 1970; Posner, 1973) on imagery, this data suggests that unfamiliar objects and pictures may not need the mediation of verbal labeling in order to be recalled.

It is apparent that more research needs to be done with nonverbal STM memory, using various age levels and samples. It is also apparent that a matched study with normal children needs to be done before any substantial generalizations can be made to a learning disabled population. The current mediational literature in STM has been monopolized by language effects (Flavell, 1970). The developmental continuum from "mediation inefficiencies" to a production of maximal mediators needs to be studied under various task conditions (e.g., stimuli used, testing procedure, experimental instructions). Since little experimental research has been done in terms of nonverbal deficiencies, more research is needed to determine what mediators are available to the subject and what causes these mediators to mediate effectively. Nonverbal STM memory in this study was not age-dependent upon the availability of a mediator but was age-dependent upon the effective use of that mediator. More perceptual cues need to be identified that will improve mediation production.

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TABLE 1

MEAN RESPONSE BIAS VALUES (C_j)

Group	Serial Positions 1	2	3	4	5	6
3-D (Objects):						
Group I*	1.568	1.338	.755	1.073	1.444	2.990
Group II**	2.159	1.440	1.092	1.089	1.510	1.728
2-D (Pictures):						
Group I	1.649	1.229	1.278	1.061	1.218	1.373
Group II	1.405	1.451	1.311	1.094	1.450	1.792

*Group I - Younger L.D. Subjects

**Group II - Older L.D. Subjects

Table 2

ITEM ASSOCIATION (A) AND CONTENT RESPONSES (C)
FOR BOTH TREATMENT AND AGE GROUPS

	Random Shape Number Sequence*											
	Percent I		Percent II		Percent III		Percent IV		Percent V		Percent VI	
Group	A	C	A	C	A	C	A	C	A	C	A	C
3-D (Objects):												
Group I	18	09	18	09	18	18	18	09	18	18	18	09
Group II	36	18	36	27	36	18	18	18	36	18	36	27
2-D (Pictures):												
Group I	27	18	27	09	27	18	18	09	18	18	18	09
Group II	36	09	36	27	36	27	36	18	36	00	36	09

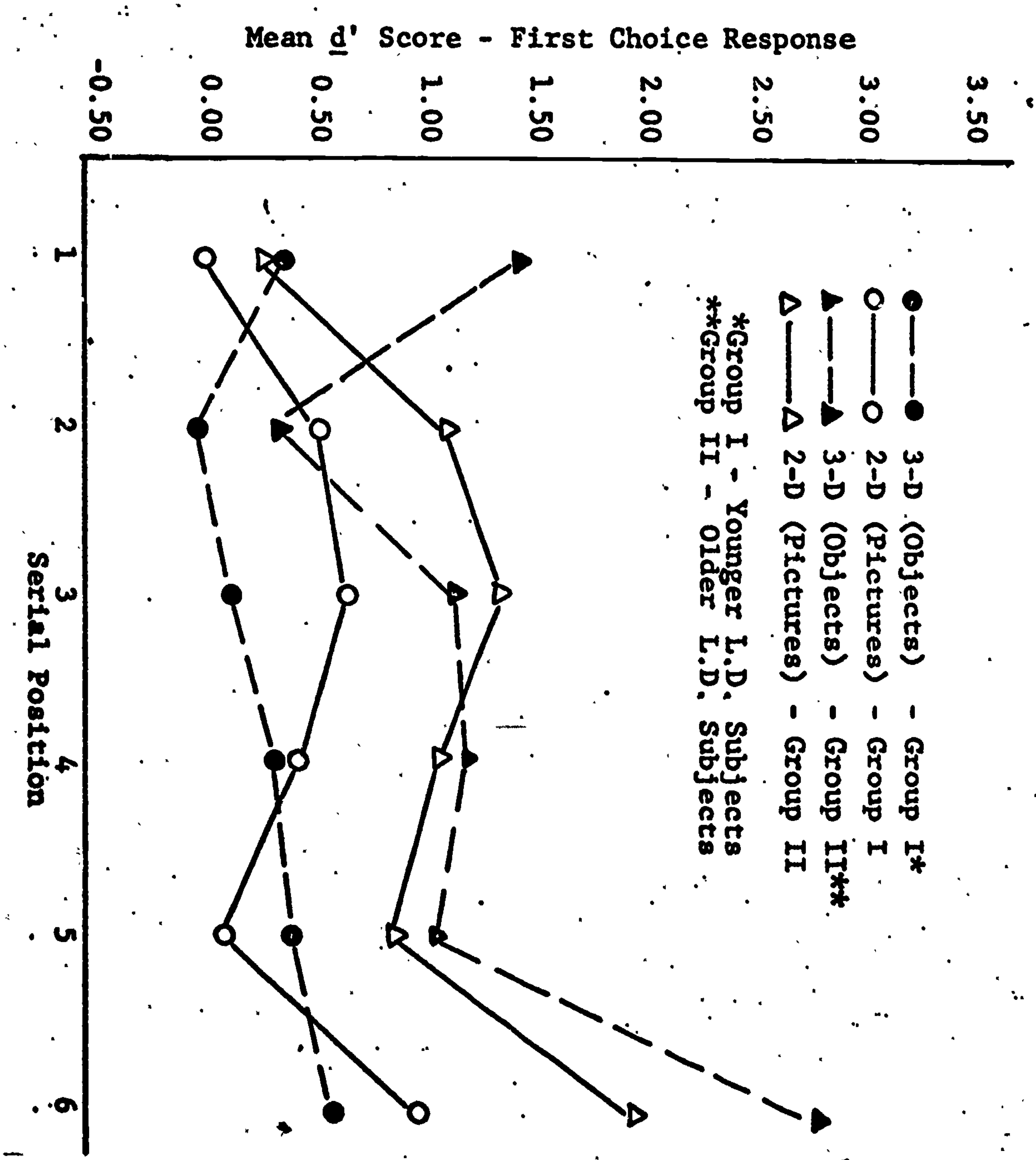
*Random number assigned to each similar item pair of the two and three dimensional stimuli.

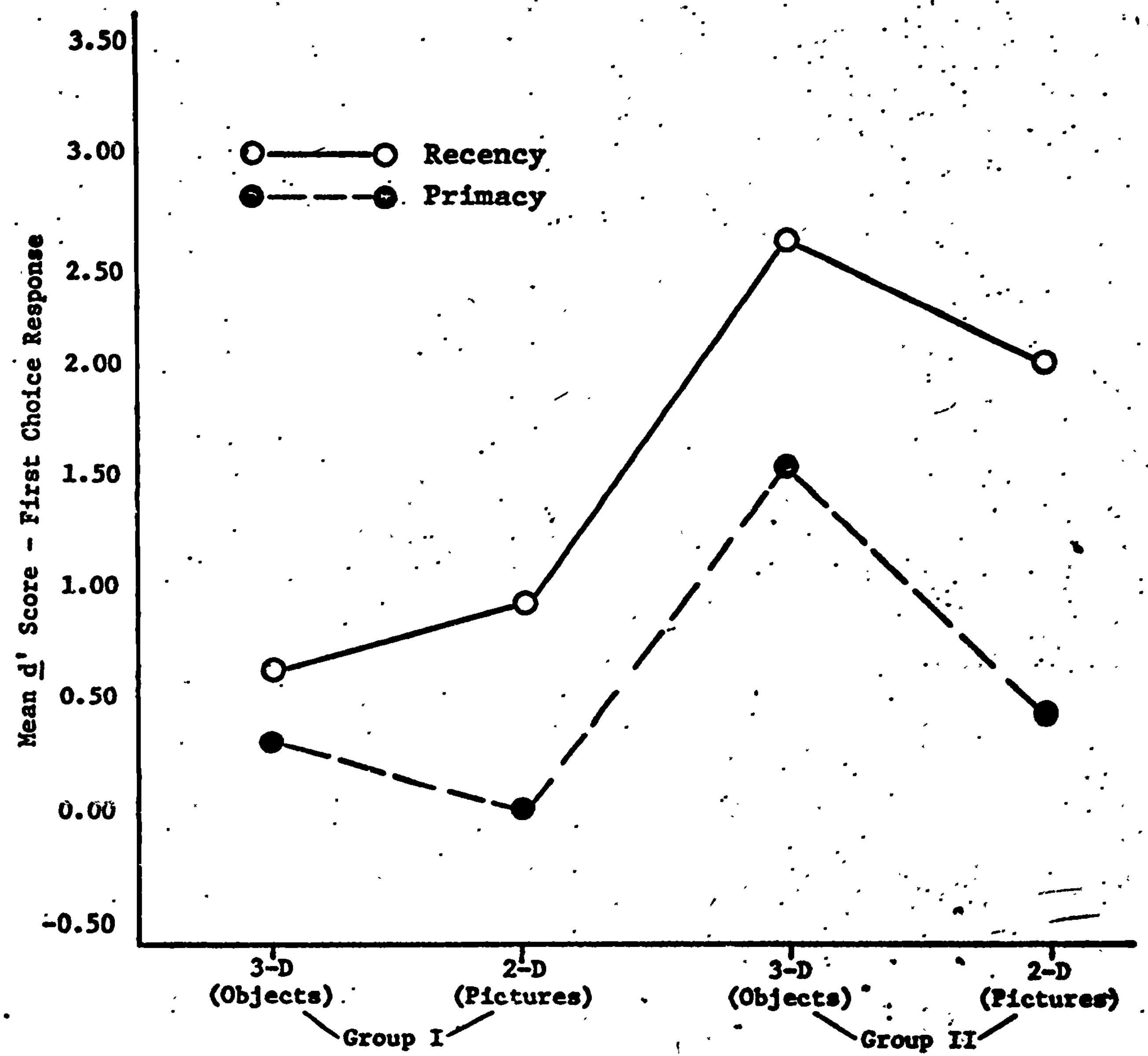
Figure Captions

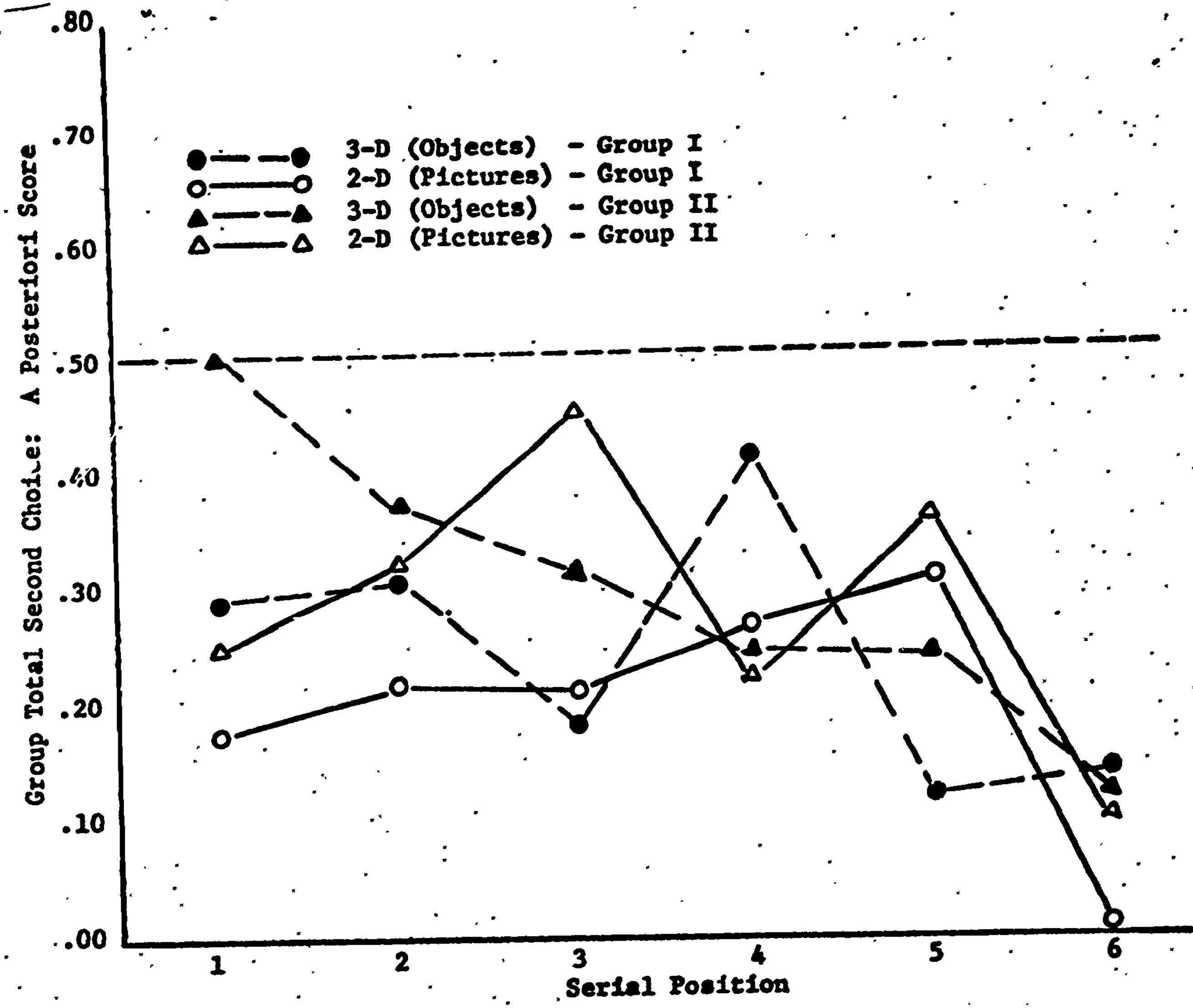
Figure 1. Mean d' first choice response as a function of dimensionality, age, and serial position.

Figure 2. Comparison of primacy and recency effects by age and dimension.

Figure 3. Group second choice a posteriori probability score by serial position.


Mean d' Score - First Choice Response
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
1
2
3
4
5
6
Serial Position
3-D (Objects) - Group I*
2-D (Pictures) - Group I
3-D (Objects) - Group II**
2-D (Pictures) - Group II
*Group I - Younger L.D. Subjects
**Group II - Older L.D. Subjects


Mean d' Score - First Choice Response
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
Recency
Primacy
3-D (Objects)
2-D (Pictures)
Group I
3-D (Objects)
2-D (Pictures)
Group II



Group Total Second Choice: A Posteriori Score
.80
.70
.60
.50
.40
.30
.20
.10
.00
3-D (Objects) - Group I
2-D (Pictures) - Group I
3-D (Objects) - Group II
2-D (Pictures) - Group II
1
2
3
4
5
6
Serial Position

Figure 3