DOCUMENT RESUME

ED 244 480 EC 162 499

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TITLE The Development of Encoding Processes in Learning Disabled Children.
SPONS AGENCY Nebraska Univ., Omaha.
PUB DATE Apr 84
NOTE 30p.; Paper presented at the Annual Conference of the American Educational Research Association (68th, New Orleans, LA, April 23-27, 1984).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Age Differences; *Cognitive Processes; Elementary Education; *Encoding (Psychology); *Learning Disabilities; Semantics; Visual Learning

ABSTRACT

The current experiment compared the development of encoding preferences in learning disabled children and non-disabled children. Both learning disabled (LD) and non-learning disabled (non-LD) boys from grades 2 and 6 were given a false recognition task. To measure the relative dominance of attributes encoded by the two groups at the two ages, study and test items were manipulated to form visual, acoustic, and semantic distractors. For both second grade and sixth grade LD subjects, visual distractors produced significantly greater numbers of false recognitions than acoustic or semantic distractors. This pattern of encoding preference was also observed with non-LD second graders. However, sixth grade non-LD subjects displayed a shift in encoding preference and were significantly more distracted by semantic than by acoustic or visual items. The results suggest that LD students do not spontaneously use the effortful semantic processing strategy of elaborative rehearsal. (Author)

The Development of Encoding Processes In Learning Disabled Children

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This research was supported by a graduate student research grant awarded to the second author by the University of Nebraska at Omaha. The authors wish to express their sincere appreciation to Barbara Means for providing them with a list of the stimulus materials. Requests for reprints may be sent to Tom Lorsbach, Department of Counseling and Special Education, University of Nebraska at Omaha, Omaha, Nebraska 68182.

Running Head: ENCODING PROCESSES IN LD CHILDREN

ABSTRACT

The current experiment compared the development of encoding preferences in learning disabled children and non-disabled children. Both learning disabled (LD) and non-learning disabled (non-LD) boys from grades 2 and 6 were given a false recognition task. To measure the relative dominance of attributes encoded by the two groups at the two ages, study and test items were manipulated to form visual, acoustic, and semantic distractors. For both second grade and sixth grade LD subjects, visual distractors produced significantly greater numbers of false recognitions than acoustic or semantic distractors. This pattern of encoding preference was also observed with non-LD second graders. However, sixth grade non-LD subjects displayed a shift in encoding preference and were significantly more distracted by semantic than by acoustic or visual items. The results suggest that LD students do not spontaneously use the effortful semantic processing strategy of elaborative rehearsal.

Theories of information processing (e.g., Bower, 1967; Underwood, 1969) generally conceive of the memory trace as a collection of attributes. Depending upon which features are selected from the stimulus event, a given memory trace may consist of a variety of attributes, ranging from superficial perceptual elements to abstract conceptual features. The process by which stimulus attributes are selected for storage in long-term memory is referred to as encoding. Initial stages of encoding are often considered to reflect the structural aspects of a stimulus, whereas subsequent encoding efforts are directed at semantic elements (Craik & Lockhart, 1972; Posner, 1978).

Hasher and Zacks (1979) have provided a framework for the conceptualization of encoding processes that integrates much of the research on developmental and individual differences in cognitive processes. Their framework assumes that at any given moment only a limited amount of mental resources are available for completing various encoding operations. Two basic ideas are expressed in their model. First, encoding processes differ in their capacity requirements. Encoding operations that demand minimal amounts of cognitive capacity are called "automatic," whereas those processes requiring significant amounts of mental resources are termed "effortful." Various stimulus attributes (e.g., temporal, frequency, word meaning) may be processed automatically. However, additional processing in the form of elaborative rehearsal or the use of other such memory strategies is considered to be effortful. The second concept of the Hasher and Zacks model states that amount of available mental capacity varies within and between individuals. The framework leads to the important prediction that developmental and individual differences are manifested only on tasks requiring the use of effortful memory processes.

Craik and Simon (1982) have observed that "deeper processing is more difficult and effortful to achieve, and that when processing resources are limited...there is a consequent failure to utilize deeper, semantic levels" (p. 99). Assuming that greater depth of processing requires more effort, and given that developmental differences exist in the amount of available processing capacity, younger children should be less apt to activate deeper, semantic codes. Support for this hypothesis may be obtained from descriptions of encoding processes in children that portray an age-related decrease in the processing of superficial sensory information and an increase in the amount of attention given to semantic attributes (Bruner, 1964; Flavell, 1970; Underwood, 1969). This developmental shift in the dominance of encoding attributes has been demonstrated with a number of studies using a false recognition procedure. Subjects are initially presented with a list of words or pictures and are instructed to remember them. Recognition memory is then tested with a list containing repeated targets, as well as distractor items bearing some relationship to the unrepeated targets. Developmental differences are typically observed in the pattern of recognition errors. The recognition errors of first and second graders are usually made with distractors bearing an acoustic relationship to the unrepeated targets. Sixth graders, on the other hand, are more apt to commit errors with distractors that are associatively or semantically related to prior study list items (Bach & Underwood, 1970; Means & Rohwer, 1976). This increase in semantic false recognitions may be attributed to the elaborative processing efforts of older children. More extensive processing of semantic information increases the likelihood that a given study item will have overlapping features with its semantic distractor. Because the two stimulus events have overlapping features, they are not well distinguished. Consequently, when the new, but semantically related, event is presented it is incorrectly judged as an "old" item.

Depending upon the paradigm used, learning disabled children are sometimes found to be deficient in the processing of semantic information. Learning disabled children, for example, often fail to use category membership to organize their recall efforts (Bauer, 1979a; Dallago & Moely, 1980; Freston & Drew, 1974; Parker, Freston, & Drew, 1975). Other studies using response latency as a dependent variable (Ceci, 1982a, 1982b; Lorsbach, 1982) indicate that, although they are slower to respond, learning disabled children display an automatic activation of semantic memory similar to that of non-disabled children. Following the framework of Hasher and Zacks (1979), Ceci (1982a) has proposed a two-process model of semantic processing which predicts developmental differences in semantic processing only on tasks requiring the use of "purposive" (effortful) processing. In several tests of his model Ceci (1982a, 1982b) has demonstrated that learning disabled children are developmentally immature in the purposive aspects of semantic processing.

The purpose of the current study was to further examine Ceci's hypothesis by comparing the encoding preferences of both learning disabled and non-disabled children. A false recognition procedure was used to compare the relative dominance of acoustic, visual, and semantic attributes for both learning disabled and non-disabled children at different stages of development. The method used for comparing the development of encoding preferences followed that which was used by Means and Rohwer (1976). Using a false recognition procedure, Means and Rohwer measured the relative strength of visual, acoustic, and semantic distractors with first and sixth grade boys and girls. Each child was initially presented with a 70-item study list comprised of black and white line drawings and their corresponding verbal labels. A 70-item test list containing visual, acoustic, and semantic distractors was then presented. Both visual and acoustic distractors produced significant numbers of false recognitions for first grade boys, while semantic distractors did not. For sixth grade boys, false recognition rates for both visual and semantic distractors were significant, while acoustic distractors failed to reach significance. This developmental shift in encoding preference is presumably the result of older children actively rehearsing the targets, as well as information bearing a synonymous relationship to those items.

The current study compared learning disabled and non-disabled boys in grades two and six. Assuming that learning disabled children fail to develop the spontaneous use of semantic strategies, older learning disabled children should display the encoding preferences of younger non-disabled children. More specifically, perceptual rather than semantic features, should be the salient memory attributes for younger, as well as older, learning disabled subjects. Support for this hypothesis may be obtained from the results of a previous study by Hynd, Obrzut, Hynd, and Connor (1978). These investigators used a word recognition task to measure the relative dominance of acoustic, orthographic, and associative attributes for learning disabled children in grades 2, 4, and 6. Although the use of printed words as stimulus items with disabled readers and the absence of a control group make it somewhat difficult to interpret their results, their findings suggest that as learning disabled children develop, increased attention is given to orthographic features over acoustic or associative attributes during a word recognition task.

METHOD

Subjects

Seventy-two male subjects participated in the experiment, 36 learning disabled and 36 non-disabled, each from the second and sixth grades of a predominantly white suburban school district. The mean chronological ages for the four groups were second grade learning disabled (8;4), second grade non-disabled (8;0), sixth grade learning disabled (11;7), and sixth grade non-disabled (12;1). Results obtained from standardized tests (Slosson Intelligence Test, Wechsler Intelligence Scale for Children-Revised) provided a mean IQ score for each group: second grade learning disabled (101), second grade non-disabled (110), sixth grade learning disabled (102), and sixth grade non-disabled (109).

All learning disabled children had been previously identified by school personnel and were receiving special education services at the time of testing. Verification of a learning disability by school district personnel was based primarily upon two criteria: (1) the child scored above the minus one standard deviation level on an individually administered intelligence test and (2) the child's standard score in one or more major academic area was 1.3 or more standard deviations below the child's ability level. The average total reading grade level (Woodcock-Johnson Achievement Test) was 1.9 for learning disabled children in the second grade and 4.1 for learning disabled children enrolled in the sixth grade.

Non-disabled subjects were selected who were demonstrating normal school progress and were not receiving any special education services. The average total reading grade level for the sixth grade non-disabled subjects was 8.4 (California Achievement Test). Although no standardized test results were available for the second grade non-disabled subjects, only those students were selected whose reading progress was considered average or above average by their classroom teachers.

Design and Procedure

The design for this experiment was a 2 x 2 x 3 mixed factorial. Grade level (second or sixth) and subject type (learning disabled or non-disabled) were the between subject factors, while code (acoustic, visual, or semantic) was the within subjects factor.

The procedure carefully followed that which was used by Means and Rohwer (1976):

> The recognition test was individually administered to each subject. Initially, subjects were informed that they would be seeing slides of various objects and hearing their names. They were instructed to watch and listen carefully and to try to remember the items.
>
> The 70-item study list was then administered at a rate of 2 seconds per item. The slides were presented by a Kodak carousel slide projector synchronized with a Wollensak cassette recorder used to present verbal labels for the slides.

After subjects had been shown the study list, they were informed that they would now be seeing and hearing an additional set of items, some of which would be repetitions of those they had already been shown. If an item consisted of a picture and label that had been given together before, subjects were instructed to respond "old." If the picture, the label, or both were ones that had not been given previously, subjects were told to respond "new." After the subjects indicated that they understood the instructions, the first six items of the test list were administered as unpaced practice items. For the practice items, the subjects were given feedback concerning the correctness of their responses. If a subject made an error on one of the distractor practice items, the experimenter explained the way in which the distractor differed from the original target item and indicated that in such instances the proper response was "new." The time interval between the termination of the study list and the beginning of the test trial depended upon a subject's performance on the practice items, but averaged around 1½ minutes.

After the subjects completed the practice items and indicated that they understood the procedure and instructions, they were told that they would be asked to respond to the rest of the test items without feedback. The subjects were instructed to respond to every item, even if unsure of their answers. The test list was administered with a 4-second interitem interval. Each slide was shown for 2 seconds, followed by a 2-second period during which the screen was blank and subjects gave their recognition responses. The subjects' oral responses were recorded by the experimenter.

Materials

Stimulus materials were line drawings of common objects on 35-mm. transparencies accompanied by orally presented verbal labels. The study list contained 6 initial practice items and 64 regular items, comprising 24 target, 12 control, and 28 filler items. Like the study list, the test list was 70 items long, consisting of 12 repeated target items, 12 distractor items (one for each of the unrepeated targets), 12 control items repeated from the study list, 12 new control items, 16 fillers (half of which were repetitions from the study list), and 6 initial practice items. The composition of the test list provided for a 50:50 ratio of old to new items.

Thus, half of the target items on a given study list reappeared at test. The repeated targets were exact repetitions of critical items on the study list. Those targets not repeated on the test list were replaced by distractor items. The distractor items were related to the original target items in one of three ways: Acoustic distractors were items with labels that were homophonous with one of the target items. Visual distractors consisted of a picture identical to that

used for one of the targets with a new label that gave it a completely different referent. A semantic distractor was composed of a label synonymous with that of a target presented with a new line drawing. Semantic distractors were drawn to be as visually dissimilar as possible to the semantic targets....

It should be noted that across the three types of target distractor relationships there is a systematic variation of the acoustic, visual, and semantic attributes. For acoustic pairs, the aural input is the same for the target and the distractor, but the line drawings (visual input) and referents (semantic content) differ. For visual pairs, the line drawings are identical, but the labels (acoustic input) and referents differ. The surface input in both modes (acoustic and visual) differs within semantic pairs, but the underlying meaning, the referent class, is the same.

A new item, unrelated to any of the target items and designated as a new control item, appeared either before or after each distractor item on the recognition test. For each distractor type, half of the control items appeared immediately before distractors and half immediately after.

Another set of items served as controls for the target items that were repeated on the test list. A control item repeated from the study list and unrelated to any of the target items appeared immediately before or after each repeated target on the test list.

Finally, a number of items were used simply to fill out the study and test lists. Twenty-eight fillers appeared on the study lists: 8 of these and 8 new fillers were included in the test list. The only difference between "filler" and "control" items was that the list position and word frequency count of control items were equated with those of target repetitions and distractors so that responses to the control items could provide an adequate baseline from which to measure experimental effects.

Six practice items appeared at the beginning of both the study and test lists. Included among the practice test items was a distractor item of each type formed from one of the practice study items.

Word frequency was controlled across critical item types and for control items. The mean frequency count (Carroll, Davies, & Richman, 1971) was 203 for the acoustic target and distractor items, 202 for the visual items, and 202 or 203 for the semantic items on a given study list. Mean word frequency was 202 for both new and repeated control items.

The distribution of the three critical item types within the study list was controlled so that the same average presentation position was maintained for each type. The number of items intervening between the appearance of a target item on the study list and the appearance of its repetition or the corresponding distractor on the test list (and likewise between the appearance of a control item on the study list and its repetition at test) was also controlled. A mean interval of 76 items with a range from 68 to 85 was maintained for the three critical item types and for repeated controls. Finally, 12 study-test lists were formed to balance list position and item effects across factors of interest. Each member of a critical item pair served as the target member of the pair on six lists, while the other member of the pair was the target item on the remaining six. (pp. 412-414)

RESULTS

The mean error proportions for both learning disabled and non-disabled children are displayed in Table I. Analyses were performed on both the corrected and uncorrected false recognition rates for the visual, acoustic, and semantic distractors. Corrected false recognition rates consisted of the difference between the false recognition rates for each distractor type and the mean error rate for new controls. Uncorrected false recognition rates consisted of the differences between the error proportions for each of the three distractor types. In each of the following analyses, the results obtained with the corrected false alarm rates paralleled those obtained with the uncorrected false recognition data. Thus, for the sake of brevity, only those analyses pertaining to the corrected false recognition data are reported.

Insert Table I about here

Analysis of the false alarm rates revealed a significant main effect of code, $F(2,136) = 16.007$, $p < .001$. Individual comparisons using the Newman-Keuls test indicated that the acoustic and semantic distractors differed significantly from the visual distractors, but not from each other. The main effects of subject type and grade level were not significant. However, the subject type x code interaction was significant, $F(2,136) = 5.408$, $p < .005$, as was the subject type x grade level x code interaction, $F(2,136) = 4.655$, $p < .01$.

In order to interpret the 3-way interaction, separate analyses were performed on the learning disabled group and the non-disabled group. Analysis of the false alarm rates in the learning disabled group revealed a significant main effect of code, $F(2,68) = 20.352$, $p < .001$, with acoustic and semantic distractors differing significantly from visual distractors, but not from each other. There was no significant effect of grade, nor did grade interact with code. These results indicate, therefore, that for both second grade and sixth grade learning disabled subjects visual attributes are dominant, while acoustic and semantic features assume a less prominent role in recognition memory.

For the non-disabled group, the effects of grade level and code did not reach significance. However, grade level did interact significantly with code, $F(2,68) = 3.957$, $p < .02$. The presence of this significant 2-way interaction in the non-disabled, but not the learning disabled, group indicates that the source of the previous 3-way interaction is due to the interactive effects of grade level and code with the non-disabled subjects.

The interactive effects of grade level, subject type, and code may be clearly seen in Figure 1, which shows the mean proportion of corrected false alarms for learning disabled and non-disabled subjects at each grade level. For learning disabled subjects the pattern of false alarm rates remains relatively constant between the second and sixth grade, with visual attributes maintaining their clear superiority. In fact, learning disabled subjects increased somewhat the amount of attention given to visual attributes between the second and sixth grade, while the false alarm rate for acoustic and semantic distractors remained at a relatively constant level. With the non-disabled subjects, however, a developmental shift in encoding preference is observed. At grade two, visual attributes are prominent, while at grade six, semantic features become more salient.

Insert Figure 1 about here

Additional analyses were performed on total false alarm rates, total miss rates, and overall error rates. Total false alarm rates varied only with subject type, with learning disabled children making a greater number of false-alarms, $F(1,68) = 5.641$, $p < .02$, than non-disabled children. Miss rates varied both with grade level $F(1,68) = 4.432$, $p < .04$; and subject type, $F(1,68) = 5.630$, $p < .02$, with sixth graders making fewer misses than second graders and non-disabled children having a lower miss rate than learning disabled children. Analysis of the overall error rates indicated that sixth graders had a fewer number of total errors than second graders, $F(1,68) = 5.619$, $p < .02$, and that non-disabled children had a lower overall error rate than learning disabled children, $F(1,68) = 13.462$, $p < .001$.

DISCUSSION

The current findings have identified some rather dramatic individual and developmental differences in the type of stimulus attributes that are encoded in memory. The pattern of results obtained with the non-disabled children is characterized by a developmental shift in encoding preferences, with younger children committing more false recognition errors on the basis of structural features and older children making more errors based on semantic attributes. This age-related increase in the amount of attention given to semantic features, and the concomittant decrease in the processing of structural attributes reflects a development in effortful semantic processing ability. In particular, these results indicate that non-disabled children spontaneously employ the use of elaborative rehearsal as a semantic strategy. During the presentation of study list items, older non-disabled children included related, semantic information in their rehearsal of target items. The availability of additional semantic information at the time of the recognition test thus resulted in greater confusion when semantic distractors were presented.

Learning disabled children, on the other hand, did not exhibit a corresponding growth in the spontaneous use of effortful semantic processing skills. The encoding preferences of learning disabled children remained unaltered with age, with visual attributes being the dominant feature, and semantic elements assuming a relatively unimportant role. These results are consistent with those obtained by Hynd et al. (1978) and confirm Ceci's (1982a) hypothesis that learning disabled children are immature in the effortful processing of semantic information. Evidence for reduced elaborative rehearsal in learning disabled children has been provided by previous studies that have shown a reduced primacy effect in immediate free recall (Bauer, 1977, 1979b; Tarver, Hallahan, Kauffman, & Ball, 1976). By using a false recognition procedure, the current study extends this observation by demonstrating that learning disabled children specifically do not spontaneously incorporate semantically related information in their rehearsal activities. A failure to engage in elaborative rehearsal leads to an unstable memory trace and therefore would explain the higher error rates that were observed with the learning disabled subjects.

A failure to develop semantic processing strategies may be conceptualized within the context of several models of information processing (e.g., Craik & Lockhart, 1972; Paivio, 1974), but is perhaps best understood within the developmental model of Bruner (1964). According to Bruner, as children develop they proceed through enactive, iconic, and symbolic modes of representation. Between the ages of five and seven, children typically rely upon internal images for representing their environment. As adolescence approaches, improved cognitive ability enables children to symbolically represent their surroundings on the basis of abstract, conceptual information. Both the current and previous findings suggest that by grade six, learning disabled children fail to spontaneously employ those verbal encoding strategies that would enable them to represent their environment in a more symbolic manner.

One possible factor that may be contributing to the failure of learning disabled children to employ elaborate rehearsal strategies is a slower rate of processing (Bauer, 1982). Encoding is time-dependent, with complex semantic features requiring more time to be processed than more superficial attributes (Posner, 1978). Individual differences in processing rate may be responsible for differences in the depth to which information is processed (cf. Kail & Siegel, 1976). One of the more reliable findings regarding learning disabled children is that they are slower to name various stimuli than non-disabled children (e.g., Eakin & Douglas, 1971; Spring & Capps, 1974) and slower to retrieve semantic information (Lorsbach, 1982). The current procedure used a 2 sec presentation rate to present study items. Although this study interval would appear to be adequate for most children, older learning disabled children may not have had sufficient time to process study items at a semantic level or to engage in the elaborative rehearsal of those items. Future studies will need to consider both strategic and nonstrategic factors when examining the nature of semantic encoding deficiencies in learning disabled children.

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FOOTNOTES

[1]From "Attribute dominance in memory development" by B. M. Means and W. D. Rohwer, 1976, Developmental Psychology, 12, pp. 412-414. Copyright 1976 by American Psychological Association. Reprinted by permission.

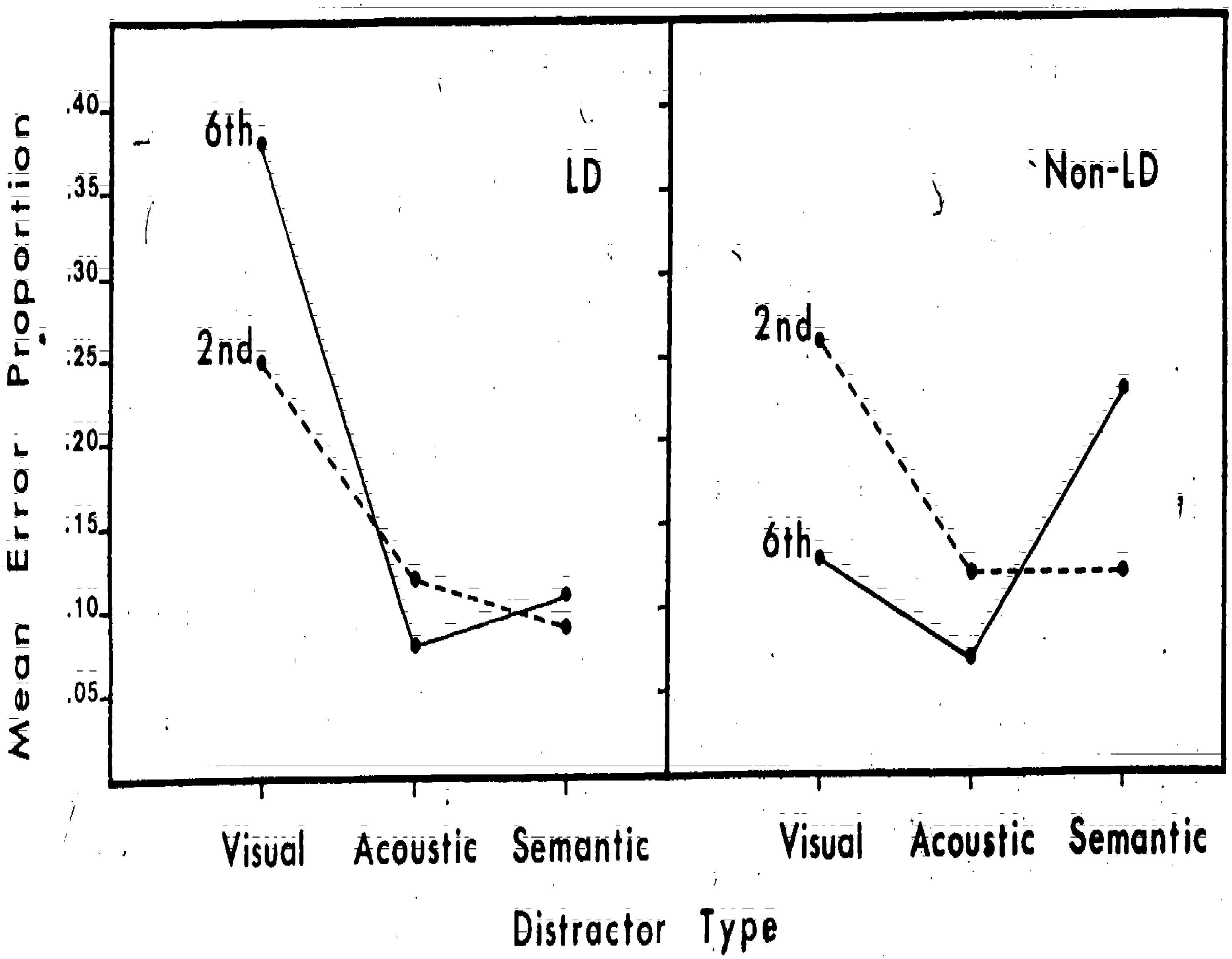
Table I

Mean Error Proportions by Item Type, Subject Type, and Grade Level

	LD			Non-LD		
Errors	2nd	6th	Total	2nd	6th	Total
False Alarms						
Acoustic distractors	.23	.15	.19	.23	.11	.17
Visual distractors	.38	.50	.44	.36	.19	.28
Semantic distractors	.19	.19	.19	.20	.30	.25
New controls	.15	.13	.14	.12	.08	.10
Other fillers	.20	.15	.18	.10	.08	.09
Total	.21	.19	.20	.17	.12	.15
Misses						
Acoustic targets	.37	.21	.29	.25	.21	.23
Visual targets	.32	.22	.27	.29	.18	.24
Semantic targets	.46	.38	.42	.35	.29	.32
Old controls	.42	.39	.41	.35	.30	.33
Other fillers	.40	.38	.39	.38	.26	.32
Total	.40	.34	.37	.34	.26	.30
Total	.31	.27	.29	.25	.19	.22

FIGURE CAPTIONS

Figure 1. Mean corrected error proportions for learning-disabled and non-disabled subjects as a function of grade level and distractor type.



Mean Error Proportion
.40
.35
.30
.25
.20
.15
.10
.05
6th
2nd
LD
Non-LD
2nd
6th
Visual
Acoustic
Semantic
Visual
Acoustic
Semantic
Distractor Type

29