Visual selective attention in learning disabled and normal boys

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Learning disabled and normal control boys were compared in a reaction time task that required same-different judgments about the size or shape of visually presented geometric forms. In one condition, the subject was told which aspect (either size or shape) to judge before the presentation of the forms; in the other condition, the subject was told which aspect to judge after the forms were presented. The results indicated that the reaction times of the learning disabled boys were significantly slower than those of the normal controls in both conditions. Evidently, deficits in selectivity are characteristic of learning disabled boys at the levels of both sensory-perceptual input and short-term memory.

Ross (1976) has suggested that attention in learning is related to stimulus selection and that a deficit in selective attention is characteristic of the learning disabled child. Selective attention refers to a child's ability to focus on task-relevant information while ignoring task-irrelevant information. Recent studies of selective attention in learning disabled children have supported Ross' suggestion by demonstrating a deficit or developmental lag of about 2 years (Tarver, Hallahan, Cohen, & Kauffman, 1977; Tarver, Hallahan, Kauffman, & Ball, 1976). These studies have used an incidental learning task developed by Hagen and his colleagues that has shown that normal children make greater use of selective attention as they approach early adolescence (Hagen, 1967; Hagen & Hale, 1973; Zukier & Hagen, 1978). Unfortunately, this task does not assess selective attention directly. Rather, selective attention is inferred from contrasts in the rates of learning of relevant (central) as opposed to irrelevant (incidental) information across trials; that is, increasing selective attention with age is inferred when the relative increase in incidental learning does not keep pace with the increase in central learning.

Using a task that allows direct measurement of a child's ability to focus attention on relevant information, Pick and her colleagues (Pick, Christy, & Frankel, 1972; Pick & Frankel, 1973) have examined the development of selective attention in normal children (Grades 2 and 6). Two experimental conditions requiring same-different judgments about aspects of visual stimuli were used: In the preinformed condition, the children were told prior to seeing the stimuli what aspect they should judge; in the postinformed condition, they were told what aspect to judge after they had seen the stimuli.

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The results indicate a developmental trend toward greater flexibility and adaptability in selective attention as children grow older. Evidently, older children are better able to exclude irrelevant information and to adjust their selective attention according to the requirements of the task so that they can recall relevant information better.

The experimental paradigm of Pick et al. (1972) was used in the present study to examine the selective attention of learning disabled boys. Ross (1976, pp. 48-49) has suggested that giving a cue before the stimulus is presented should enable a child to attend selectively (and more quickly) to the relevant dimension of the task, whereas giving a cue after the child has viewed the stimuli should not. In the latter condition, the child would have to sort out the relevant and irrelevant dimensions from memory, which would take much longer. If learning disabilities are characterized by a deficit in selective attention, as suggested by Ross and shown by Tarver and her colleagues (Tarver et al., 1976, 1977), learning disabled children should make attentional judgments more slowly than normal children; moreover, learning disabled children should make judgments much more slowly in the absence of a cue that facilitates visual selection. These expectations were tested in the present experiment.

METHOD

Subjects

Twenty-eight boys ranging in age from 10.2 years to 13.2 years (mean = 11.23 years) participated in the experiment. All of the boys had normal visual acuity as measured by the School Vision Tester (Orthorater). Fourteen of the boys, diagnosed as learning disabled, met the following criteria: (1) normal intelligence, ranging in IQ from 85 to 130, as measured by the WISC-R; (2) absence of primary visual, motor, or hearing impairment; (3) absence of primary emotional disturbance as indicated by prior diagnoses; (4) absence of known central organic impairment; (5) adequate educational and cultural opportunities, as reflected in a middle- to upper middle-class socioeconomic status (SES); and (6) evidence of a primary deficiency in language

Table 1
Psychometric Profile of the Learning Disabled Group
at the Time of Diagnosis

Source	N	Mean	SD	SE
Age at Testing	14	11.23	1.58	.42
Chronological Grade Placement	14	6.21	1.58	.42
Actual Grade Placement	14	4.21	1.58	.42
WISC-R (Full-Scale IQ)	14	105.21	8.29	2.22
WISC-R (Verbal IQ)	14	101.71	9.67	2.58
WISC-R (Performance IQ)	14	109.07	10.62	2.84
WRAT (Spelling)*	14	4.67	1.32	.35
WRAT (Arithmetic)*	14	5.22	1.16	.31
Gilmore Oral Reading Accuracy	12	4.50	1.48	.43
Berry Test**	13	10.10	1.60	.44

*1965 edition.

**Berry test of visual-motor coordination (MA).

learning skills, as reflected by at least a 1.5-year discrepancy between performance on the spelling or arithmetic sections of the Wide Range Achievement Test (WRAT) or the Gilmore Oral Reading Test and expected grade placement based on chronological age (see Table 1). None of the learning disabled boys was taking therapeutic drugs.

Fourteen normal control boys (age: mean = 11.40 years, SD = 1.48, SE = .36) were matched with the learning disabled boys on age, intelligence, and SES. In addition, boys in the normal control group met the following criteria: (1) nonfailure in school and (2) average school performance as defined by school grades equal to or better than a "C." The intelligence of the normal control boys was measured by the Otis-Lennon Mental Abilities Test (IQ: mean = 108.04, SD = 9.45, SE = 2.43).

Apparatus and Materials

During the experiment, a Carousel projector, equipped with a shutter and timer, projected 96 35-mm slides containing pairs of black geometric forms onto a 20 x 28 cm rear-projection screen. The subject was seated a comfortable distance (about 46 cm) from the screen. The forms projected from each slide varied in shape (circle, square, triangle, hexagon, diamond, and pentagon) and size (large—approximately 15 x 13 cm; small—approximately 9 x 8 cm).

The 96 slides depicting pairs of forms were divided into two identical 48-slide sets. Each set contained 12 slides of four basic types, defined by the physical similarities or dissimilarities between the forms: (1) same size, same shape; (2) same size, different shape; (3) different size, same shape; (4) different size, different shape. Judgments about shape were elicited from the subjects for 6 of the 12 slides for each basic type, and judgments about size were elicited for the other 6 slides. One 48-slide set was used during the preinformed condition, and the second set of 48 slides was used during the postinformed condition. The aspect judged by the subjects for a slide contained in the first set was changed for that slide when it was judged in the second set. For example, if "shape" was judged for a particular slide in the first set, "size" was judged for that slide in the second set. The order of presentation of the individual slides within each 48-slide set was randomized.

An additional 10 slides were used during the practice trials. The pairs of forms on these slides reflected shape and size variations similar to those used during the experimental trials. As part of a standardized set of instructions, each child was given five practice trials before each condition of the experiment was run; these were repeated, if necessary, until the subject understood the task.

Procedure

Each boy participated in both conditions of the experiment. The preinformed condition was administered first, followed

directly by the postinformed condition. The order of presentation was not counterbalanced because performance in the preinformed condition could be influenced by prior performance in the postinformed condition.¹

Preinformed task. The child was shown the projector and screen and was told that he would be asked to judge, as quickly as possible, whether the sizes or shapes of the two forms were the same or different. To begin a trial, the experimenter said "ready," which was the signal for the child to look at the screen, to listen for the aspect to be judged, and to wait for the forms to appear. The experimenter then said either "size" or "shape" and simultaneously activated the projector and timer by depressing a switch. When the child responded with either "same" or "different," the experimenter released the switch, which removed the forms from view and stopped the timer. After recording the response and its latency, the ready signal for the next trial was given. Five practice trials were given before the experimental trials were started. Verbal encouragement was provided by the experimenter throughout the task. The boys were asked to respond as quickly as possible without making errors.

Postinformed task. After completing the preinformed task, the child was told that the forms would now disappear from view before the experimenter would say which aspect to judge. The experimenter emphasized the figures would only be in view a short time, and since it would not be known in advance which aspect was to be judged, they should be studied carefully. The experimenter said "ready" and then activated the projector displaying the forms for 1 sec. At the end of 1 sec, the shutter closed in front of the slide while the experimenter simultaneously informed the child which aspect to judge (size or shape) and started the timer. The latency and accuracy of the child's response were recorded, and the next trial was started. As before, the child was encouraged to respond as quickly as possible without making errors.

RESULTS

The basic data were the mean reaction times for each boy under each condition for each type of judgment and aspect. Four mean reaction times were computed under each condition (preinformed and postinformed), one for each judgment by aspect combination: same size, different size, same shape, and different shape. Each mean represented the combination of reaction times from 12 trials; only reaction times for correct judgments were included.²

An analysis of variance, involving four within-subjects variables—conditions (preinformed, postinformed), groups³ (learning disabled, normal control), aspects (size, shape), and judgments (same, different)—was applied to these mean reaction times, revealing significant effects for groups [$F(1,13) = 5.39$, $p < .04$], for judgments [$F(1,13) = 30.53$, $p < .001$], and for the Groups by Judgments interaction [$F(1,13) = 8.88$, $p < .02$]. No significant effects for conditions or aspects or any of their interactions were obtained.

The significant effect for groups indicated that the mean reaction times of the learning disabled boys (1.48 sec) were slower than those of the normal controls (1.21 sec). The significant effect for judgments indicated that the mean reaction times for "same" judgments (1.26 sec) were faster than those for "different" judgments (1.42 sec). The significant Groups by Judgments

interaction was analyzed via the application of Cicchetti (1972) multiple-comparison tests, which allow the direct pairwise comparison of unconfounded means. These tests revealed that the learning disabled boys made "different" judgments significantly more slowly ($p < .05$) than the normal control boys did. (The means were 1.60 and 1.25 sec, respectively.)

The nonsignificant conditions and Conditions by Groups interaction effects indicate the latencies were equivalent across conditions for each group; the mean latencies under the preinformed and postinformed conditions were 1.49 sec and 1.47 sec for the learning disabled boys and 1.22 sec and 1.20 sec for the normal control boys. Clearly, Ross's (1976) suggestion that the postinformed condition would present greater difficulty for children was not confirmed.

Additional analyses applied to the errors made by the subjects revealed that the error rate for the normal controls, 2.5%, was similar to that obtained by Pick and her colleagues (Pick et al., 1972; Pick & Frankel, 1973), whereas the error rate for the learning disabled subjects, 5.5%, was higher. A Wilcoxon matched-pairs signed-ranks test showed this difference to be significant ($Z = 3.11$, $p < .01$). Similar tests comparing preinformed errors with postinformed errors, size errors with shape errors, and "same" errors with "different" errors did not reveal any additional significant differences.

DISCUSSION

The longer reaction times of the learning disabled boys are consistent with both recent theoretical suggestions (Ross, 1976) and previous experimental findings (Tarver et al., 1976, 1977). Clearly, learning disabled boys are deficient in their use of selective attention. However, the results did not support Ross' suggestion that children would make postinformed judgments more slowly than preinformed judgments; instead, the reaction times were similar in each condition. This failure to find a significant difference between the preinformed and postinformed reaction times may have been due to the simplicity of the stimuli used and the judgments required. The use of more complicated stimuli and judgments might result in differences as Ross suggests.

More of the nature of the deficit in selective attention was revealed by a careful examination of the requirements of each experimental condition. In the preinformed condition, the relevant aspect of the forms was known in advance, allowing attention to be directed selectively to the relevant aspect while the irrelevant aspect was ignored. In the postinformed condition, the relevant aspect of the forms was not known until the forms were removed from view: Hence, attention could not be directed separately to either aspect; rather, it had to be directed to both aspects, with the resulting information stored in memory for use later. In other words, the preinformed condition assessed the speed of attentional selectivity at the level of sensory-perceptual input, whereas the postinformed condition assessed the speed of attentional selectivity at the level of short-term sensory memory.

The significant difference between groups obtained across both experimental conditions indicates that the learning disabled boys took longer to focus on the relevant aspect of the forms at both the sensory-perceptual input and short-term or sensory memory levels. This result suggests that the deficit in selective attention extends beyond immediate sensory-perceptual input

and includes short-term or sensory memory as well. Possibly, the problems of learning disabled children with selective attention may be a subset within a larger, more pervasive set of problems with selectivity in general, which involve perception, memory, and cognition. This possibility can be tested with the same basic experimental technique used in the postinformed condition by simply extending the delay between the stimulus offset and the cue. A general problem in selectivity should be reflected in longer reaction times for the learning disabled boys across a wide range of delays involving both short- and long-term memory.

Additional information about the differences between the attentional processing of learning disabled and normal control boys was provided by the significant Groups by Judgments interaction. The learning disabled boys were significantly slower at making "different" judgments than the normal controls were. One possible explanation for this difference is that the learning disabled boys appeared to use a serial search strategy, in which comparisons were made one at a time; that is, they may have searched first for similarities between the forms and then subsequently looked for differences. Hence, judgments of "different" would require an additional step within a serial search strategy oriented to similarities first. In contrast, the normal controls appeared to use a parallel search strategy, in which both comparisons were made simultaneously and a response was initiated as soon as either a similarity or a difference was detected.

This hypothesis of greater use of a serial search strategy by the learning disabled boys would account for the additional time it took them to make "different" judgments (mean difference = .35 sec). Moreover, the occurrence of this pattern in both conditions indicates a lack of flexibility in the use of selective attention. Connor and Serbin (1978) have shown a developmental change from serial to parallel processing in normal children by 10 years of age. Learning disabled children may still be using a serial processing strategy at 12 years of age or older, which may be closely related to their more general delay in the use of selective attention. The quantitative nature of this lag in selective attention in comparison with normal children would suggest that traditional methods of instruction would be effective in helping to remediate their attentional deficits. Additional research is needed to clarify the extent to which teaching more appropriate strategies can help modify the performance of learning disabled children to allow greater flexibility in the use of selective attention.

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NOTES

1. According to Pick and her colleagues, the postinformed task requires attention to all aspects of the forms, since the

relevant aspect is not known until the pair has disappeared from view; a child who has performed this condition first might tend to use the same attentional strategy even if he were capable of directing his attention only toward the relevant aspect.

2. When an error occurred during the initial presentation of a slide, the trial was repeated in an unobtrusive manner at the end of the trials for that condition; the latency from this presentation was used in the analysis.

3. Each learning disabled boy was carefully matched with a normal control boy on age, IQ, and socioeconomic status. Thus, group was treated as a within-subjects variable in this analysis.

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