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ABSTRACT

The effects of a visual motor training program that attempts to teach 5-year-olds the underlying cognitive structures used in copying geometric designs are assessed. The Design Board Program teaches the child a systematic method for analyzing complex two-dimensional graphic patterns. It is based on the theory that accurate replication of geometric designs depends on the child's ability to view a design as though it was a construction of individual elements arranged on a matrix of vertical and horizontal coordinates. Ten children participated in the experiment, 5 of whom received training during the course of the year. Each child, in turn, attended daily training sessions, lasting 15-20 minutes, for an average of about 20 sessions. The five performance subtests of the Wechsler Preschool and Primary Scale of Intelligence were individually administered to all the children at six-week intervals. The results, when the trained and non-trained children were compared, seem to support the hypotheses that the Design Board training program has an immediate, positive effect upon the skills involved in copying designs, and that the effect is generalized to other psychomotor tasks. (PR)

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Effects of Design Board Training on the Performance Scale and Subtests of the WPPSI

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Effects of Design Board Training on the Performance Scale and Subtests of the WPPSI*--Rosner (1)

One indication of a child's visual-motor development is his ability to copy geometric designs. Gesell (1941), Starr (1961), and others have published data supporting the hypothesis that copying skills are a function of chronological age. The Wechsler Preschool and Primary Scale of Intelligence (WPPSI), (Wechsler, 1967), contains a copying subtest, suggesting that insights to a child's mental age also may be gained from evaluating his capacity to reproduce certain geometric designs. Jensen (1969) seems to be supporting the importance of both chronological and mental age in the statement: "the child of five who has been taught to copy the diamond seems to have learned something different from what the seven-year-old 'knows', who can do it without being 'taught'. Though the final performance of the five-year-old and the seven-year-old may look alike, we know that the cognitive structures underlying their performance are different."

The purpose of the present study was to assess the effects of a visual-motor training program that attempts to teach five-year-olds the underlying cognitive structures, the analytical decoding and encoding skills, used in copying geometric designs. Two questions were asked: 1) To what extent can training improve a child's copying skills? 2) What is the effect of the training on other psycho-motor behaviors that have been identified as containing cognitive factors.

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Training Program

The Design Board Program (Rosner, 1969) is based on the rationale that accurate replication of geometric designs depends upon the child's ability to view a design as though it was a construction of individual elements arranged on a two dimensional matrix of vertical and horizontal coordinates. The program begins by presenting to the child very simple designs, printed on matrices for which the coordinates are explicitly indicated. The child reproduces the designs on matching matrices, stretching rubber bands on a peg board. As skills are acquired, additional coordinates are introduced into the matrix, more complex designs are presented and a matching printed matrix, upon which the child draws the reproductions, replaces the peg board and rubber bands. Finally, the coordinates of the matrix are gradually faded and the child is taught to "imagine" their presence. That is, he is taught to view and copy the design as though the coordinates of the matrix were present. Figure 1 shows six representative levels of the program. Pattern 1-a is representative of a beginning level. Pattern 1-f is representative of one of the terminal objectives.

Insert Figure 1

The training program's major purpose is not to teach the child to draw specific geometric shapes. Rather, its overall objective is to teach visual analysis and synthesis skills; visual-motor behaviors that may be generalized to a variety of situations, including the copying of geometric designs.

Psychomotor Skills Testing

The WPPSI is composed of a battery of tests designed to appraise the mental development of 4- to 6-year-old children. Both verbal and performance subtests are included. The verbal tests are based on the child's knowledge of vocabulary, arithmetic, similarities (categories), the ability to reason in certain situations, and general information. The performance tests probe the child's ability to solve visually presented problems: copying geometric designs, a coding task (Animal House), pencil and paper Mazes, Block Design constructions, and a Picture Completion test. Of the five performance subtests, only Picture Completion appears to contain a factor dependent upon prior knowledge and is the only one of the five that requires a verbal rather than a visual-motor response. The other four tests depend upon the child's ability to use existing visual information to develop strategies for solving structured problems.

The WPPSI Performance subtests provide a convenient method for assessing certain psychomotor skills that have been related to general intelligence. The Design Board Program teaches the child a systematic method for analyzing complex two-dimensional graphic patterns. It was predicted, therefore, that children who were trained would produce higher WPPSI Geometric Design subtest scores than those who had not been trained. It was anticipated also that, since the Design Board Program aims at teaching skills that can be generalized, gains may be expected not only in the copying subtest, but in other subtests as well.

METHOD

Subjects

The subjects, two girls and eight boys, were enrolled in the kindergarten of an elementary school in Pittsburgh. At the time of the first testing (December, 1969), they ranged in age from 5 years, 1 month to 5 years, 9 months. The median age was 5 years, 4 months. All were given the performance subtests of the WPPSI. Their scaled scores ranged from 40 to 58, (mean = 50.8; S.D. = 6.6) placing them in the "average" category according to Wechsler's designations.

Research Design

A multiple baseline research design, as described by Revusky (1967), was modified for the purpose of this experiment. This design, developed especially for experiments with irreversible consequences, requires that baseline data initially be obtained from each subject. Experimental treatment is then administered to one subject, chosen at random. The subjects who do not receive experimental treatment serve as controls. The entire group is retested at the completion of the treatment period. A second subject, again randomly selected, is then provided with the experimental treatment, the remainder of the <u>untreated</u> subjects continuing to serve as controls. Measures are repeated at the completion of a second treatment period. The procedure is repeated for the third, fourth, etc., subjects until everyone in the sample has received the treatment. "The statistical method involves ranking the scores in each subexperiment; the rank of the experimental subject is the rank outcome of the subexperiment. The statistic, R_n, is the sum of the rank outcomes of the experimental subjects in each subexperiment." (Revusky, 1967). In this study, subjects who were not receiving the experimental treatment received no alternative treatment.

Training

In accordance with the research design, one child was randomly selected for training. Daily training sessions, lasting 15 to 20 minutes, were conducted by one of the authors in a separate room within the school building, while the other children remained in their classroom. The training period ranged from 15 to 22 daily sessions, with an average of about 20 sessions.

When the initial experimental subject had achieved the terminal behavior of the Design Board Program, all subjects were retested with the same WPPSI performance subtests. A second subject then was chosen at random from the remaining nine children and the training was repeated. A total of five children were trained, following this design. Every child achieved the terminal behavior of the Design Board Program except the last, Subject G. In this instance, summer recess commenced before the terminal objective was completely achieved.

Testing

The five performance subtests of the WPPSI were individually administered at one sitting; all testing was done by one person (not the trainer). All ten children were tested (except in Measure 5 whe· two of the non-trained subjects were not available for testing) five times between December, 1969, and June, 1970, at approximately 6-week intervals.*

Results

Table 1 shows the rank outcomes of each subexperiment and the R_n values for each WPPSI subtest, as well as for combined totals. These data indicate, for example, that the percentage of change from baseline in the subtest scores of the trained subject in the first subexperiment ranked 3 among the 5 in Animal House and Picture Completion. This same subject, however, demonstrated the highest percentage of change within the group (rank outcome = 5), in all of the other subtests as well as the combined totals listed under subexperiment 1.

The second subexperiment data refers to the four subjects not trained in the first segment. The rank outcome of 2, shown in the Animal House row, indicates that the trained subject of that subexperiment showed less change in that subtest score than two of the three control subjects. Similarly, the rank outcome of 2 in the third subexperiment indicates that the Animal House score of that trained subject showed more change than only one of the two remaining control subjects. The data of subexperiment 4 of that same subtest indicates that the trained subject showed less change in scale score than did the one remaining control. The last subexperiment automatically yields a rank outcome of 1 in that only one subject remains; the other four had already been trained. The R_n value of 9, the sum of the five subexperiments' rank outcomes, is not statistically significant. Higher, but still not significant, R_n values are shown for Picture Completion, Mazes and the 5 subtest total.

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* WPPSI subtest scores of the 10 Ss are available from author upon request.

The Geometric Design F_{R} value of 15, significant at the .01 level, indicates that the trained subject of each subexperiment always ranked highest in percentage of change as determined by testing immediately following the treatment. Significant results (.05) are also shown in the Block Design subtest and the 4 subtest total, omitting Picture Completion data. This latter computation was performed because the Picture Completion subtest is the only one of the five that does not sample visual-motor behavior.

Insert Table 1

Comparisons with Non-Trained Children

The Revusky design offered no opportunity to study the longer term effects of training. To answer questions regarding the retention and generalization of skills, we compared the data of the trained (E) and non-trained (C) group. As described above, five children received training, five did not. Table 2 shows the mean scale scores of both groups at the initial (M-1) and final (M-5) measures and the t-value representing the intra-group changes that occurred between M-1 and M-5. As shown, the scores of Group E changed significantly in all subtests but Animal House, and in Total Scale. The scores of C changed significantly in only two subtests, Picture Completion and Block Design.

Insert Table 2

Figure 2 illustrates the changes in the mean scale scores of E and C as listed in Table 2. The consistently steeper slope of E is obvious in all of the subtests as well as the total. As shown, C's initial mean scores were higher than those of E in four of the six graphs. In only one of these (Mazes) does C remain ahead at Measure 5, and even here the slope of E's change is appreciably steeper. In the two graphs where E's mean scores were higher at M-1, the gap between the two groups is much wider at M-5. The Geometric Design graph is particularly interesting. The mean score of the control group is precisely the same at M-5 as it was at M-1. These are, as noted, scale scores. Hence, although the copying skills of C may well have improved, it was only at the rate predicted by the scoring scale of the test.

Insert Figure 2

The differences between groups at M-5 also were calculated with an analysis of covariance, treating the M-1 scores of E and C as covariates. No significant differences were shown in any of the individual subtests. A significant difference, however, ($F = 10.76$; $df = 1/7$; $p < .05$) was shown between E and C in their M-5 full scale totals.

Discussion

Before proceeding with the interpretation of these results, it must be noted that changes in score, sometimes quite large, are normally found on WPPSI retest. Wechsler (1967) reports that "Of the 50 children [in a WPPSI retest study] one half gained from 0 to 9 Full Scale IQ points on retesting, and the remaining half of the sample was divided about equally between those who lost IQ points on retesting and those who gained 10 points or more." The data reported here tend to support this statement. Wechsler does not provide information regarding the effect of closely spaced, repeated testing such as was carried out in this experiment. Our results, therefore, cannot be viewed as scores that retain predictive validity insofar as the assessment of intelligence is concerned, nor are they to be considered as a judgment of the reliability of the WPPSI performance scale. Rather, these data are important only because they provided a means for measuring the apparent effect of training upon the psychomotor skills of a sample of 5-year-old children.

The problems of learning from repeated testing, and of training behaviors that are related to normal development, are very apparent in this study. For example, one subject in the non-trained group demonstrated markedly improved skills without training. Certain effects of training seem to be evident, however, despite the vulnerability of: (1) the test items to practice, and (2) the sensitivity of the test statistic R_n.

The Ravusky design is a demanding one. It imposes strict constraints. Very little leeway is provided in attaining a statistically significant R_n value, since not only must change occur consistently--it must be evident immediately following the treatment and be of sufficient magnitude to affect intra-group rankings. As discussed above, significant changes were shown in Geometric Designs, Block Designs, and the four subtest total that omits Picture Completion, indicating that the training did have an immediate affect on copying skills and that the effect was generalized to other visual-motor tasks.

This also appears to be indicated by the intra- and inter-group comparisons within and between E and C. Admittedly no substantive conclusions can be drawn from the data illustrated in Figure 2, albeit that E's scores consistently improved more than C's between M-1 and M-5. Nonetheless, the consistent pattern of change shown in each of the subtests strongly suggests that the two groups were much less alike at the conclusion of this study than they had been at M-1. Referring again to the Geometric Design graph, the stability of C's scores shows that copying skills are not as susceptible to change from repeated testing as are some of the other behaviors sampled by the WPPSI subtests. This was also noted by Wechsler in his test-retest reliability data. Implicit in such an observation is an acknowledgment that the improved copying skills of E, given that the test items were not taught specifically nor approximately, are evidence of the power of the training program in teaching something more than the ability to copy designs.

Finally, the analysis of covariance of the full scale scores of E and C, as mentioned above, indicates that the two groups, relatively alike at M-1 ($t = 0.45$; $df = 8$; $p =$ N.S.), were indeed different at the conclusion of the study in more than the single subtest of Geometric Designs.

Conclusion

The hypotheses on which this study was based seem to be supported: (1) The Design Board training program has an immediate, positive effect upon the skills involved in copying designs, and (2) The effect is generalized to other psychomotor tasks.

The study provides strong support for a method for teaching analytical psychomotor problem solving strategies to 5-year-old children; strategies that may be applied in a variety of situations. Teaching a pre-school child to analyze and reconstruct concrete visual data in a reliable manner may not increase his "intelligence," but one can argue strongly that it does provide him with an organized method for processing pre-symbolic visual information. This, in turn, should result in more efficient handling of those visual data as required for coding and recoding at a symbolic level. Hence, although the child may not "know" more, his capacity to receive, order and relate visual information--cognitive structures underlying performance--will be enhanced.

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Table 1

Subexperiment Rank Outcomes and R_n Values for 5 WPPSI Subtests and Combined Totals

Test	Rank outcome of Experimental S in each subexperiment					R_n Value	Significance Level
	1	2	3	4	5		
Animal House	3	2	2	1	1	9	N.S.
Picture Completion	3	3	2	1	1	10	N.S.
Mazes	5	3	3	1	1	13	N.S.
Geometric Designs	5	4	3	2	1	15	.01
Block Designs	5	4	3	1	1	14	.05
5 Subtest Total	5	4	2	1	1	13	N.S.
4 Subtest Total (minus Pic. Com.)	5	4	3	1	1	14	.05

Table 2

Mean Subtest and Total Scale Scores for Groups C and E
at Measures 1 and 5

Test	GROUP E M-1	GROUP E M-5	GROUP E t	GROUP C M-1	GROUP C M-5	GROUP C t
Animal House	[illegible].8(2.0)	12.4(2.3)	2.35	9.6(2.1)	10.2(1.5)	1.0
Picture Completion	10.8(2.4)	15.0(3.0)	3.9[illegible]**	9.4(0.5)	12.2(2.2)	3.49*
Mazes	[illegible]	[illegible]	4.[illegible]**	10.[illegible](2.4)	12.0(0.7)	1.3
Geometric Designs	[illegible]	[illegible]	3.[illegible]*	10.[illegible](2.7)	[illegible](2.6)	0
Block Designs	[illegible]	[illegible]	7.[illegible]***	11.[illegible]	[illegible].0(2.9)	2.8*
5 Subtest Total	[illegible]	[illegible]	[illegible]***	[illegible]	[illegible]	2.34

* p < .[illegible]

** p < .[illegible]

*** p < .[illegible]

Figure 1

Representative Levels of Design Board Program

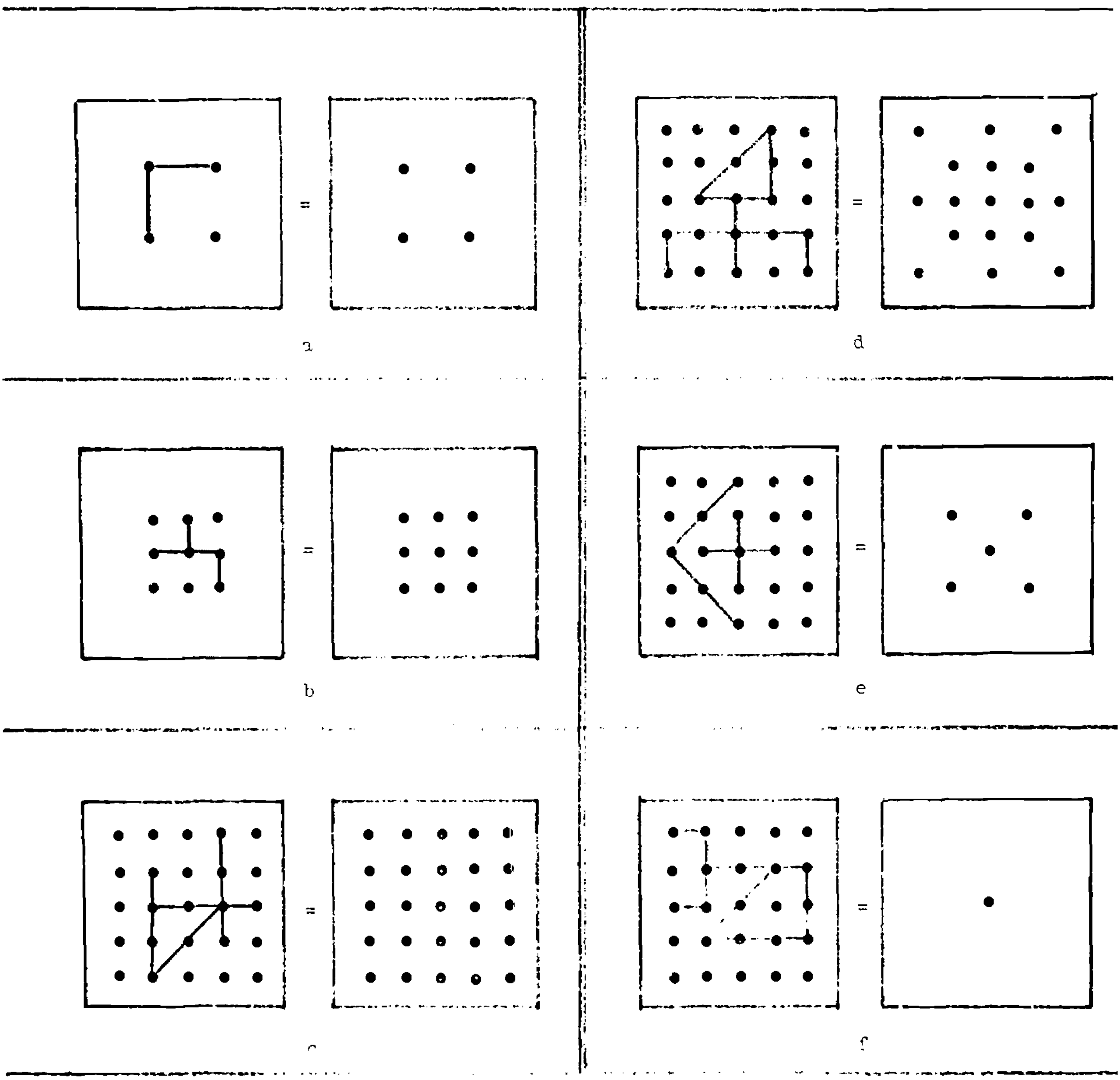

Figure 2

Mean Scale Score of Experimental and Control Groups at Measures 1 and 5