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AUTHOR Rosner, Jerome
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THE VISUAL ANALYSIS TEST: AN INITIAL REPORT

JEROME ROSNER

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Jerome Rosner

Learning Research and Development Center
University of Pittsburgh

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ABSTRACT

A copying test (VAT) is described in which the test items can function as teaching objectives with the expectation that acquiring competency in the represented behaviors will be generalized to other visual-motor tasks. Six hundred and sixty-seven kindergarten, first- and second-grade children were tested. Results show: (1) a reliable scoring method (Interrater r = .98); (2) a broad range of individual differences between and within the three age groups; (3) significant predictive validity to the norm-referenced Rutgers Drawing Test (K and Gr. 1: VAT-Rutgers Form A, r = .80; Gr. 2: VAT-Rutgers Form B, r = .68). Item difficulty is analyzed and implications are discussed.

The Visual Analysis Test: An Initial Report

Jerome Rosner

University of Pittsburgh

The main intent of this paper is not to introduce into the literature yet another copying test that is designed solely to measure visual-motor development. There are enough already. The Gesell Copy Form Test (Ilg & Ames, 1964), the Bender-Gestalt Visual Motor Test (Bender, 1938), and the Rutgers Drawing Test (Starr, 1961), to name only a few, have been shown to be effective instruments for assessing a child's ability to copy geometric designs. Though the tests differ somewhat in their designs, testing conditions, and scoring systems, they all probe the same general behavior: that is, the child's ability to replicate, with a drawing instrument, geometric designs of varying complexity. It has been very well established that certain designs are more difficult than others; that the 3-year-old usually can copy a circle fairly accurately, but not a triangle; that the 5-year-old may be expected to approximate a triangle, but not a diamond; and so on. From an accumulation of normative data, scoring scales have been determined that enable one to infer developmental levels from a child's responses to a copying test (e.g., Koppitz, 1964).

In recent years there has been increased attention devoted to programs that attempt to foster school readiness. There also has been an awakening to the relatively high incidence of perceptual dysfunction among elementary school children who are performing inappropriately in

Special acknowledgement is given to Susan M. Tutko, Secretary to the Perceptual Skills Project, for her assistance in standardizing the scoring method. It was a major contribution to this study.

the classroom (see Rosner et al., 1969). Both of those factors have stimulated the development of visual-motor training programs designed to teach copying skills and other related functions. Some are discrimination training programs; others involve the child in tracing various designs and using templates. Their apparent goal is to teach the child to copy certain shapes; often the same shapes that appear in the tests. Their inferred goal seems to be that having learned to copy a diamond, a behavior expected from a 7-year-old, the child should be able to demonstrate all of the visual-motor skills of a 7-year-old. The data, thus far, do not appear to support this position.

The main intent of this paper is to describe a copying test in which the test items can be used as teaching objectives with the expectation that acquiring competency in the behaviors they represent will be generalized to other related tasks. The items represent some of the objectives of the visual-motor component of the Perceptual Skills Curriculum (Rosner, 1969), a product of the Learning Research and Development Center at the University of Pittsburgh.

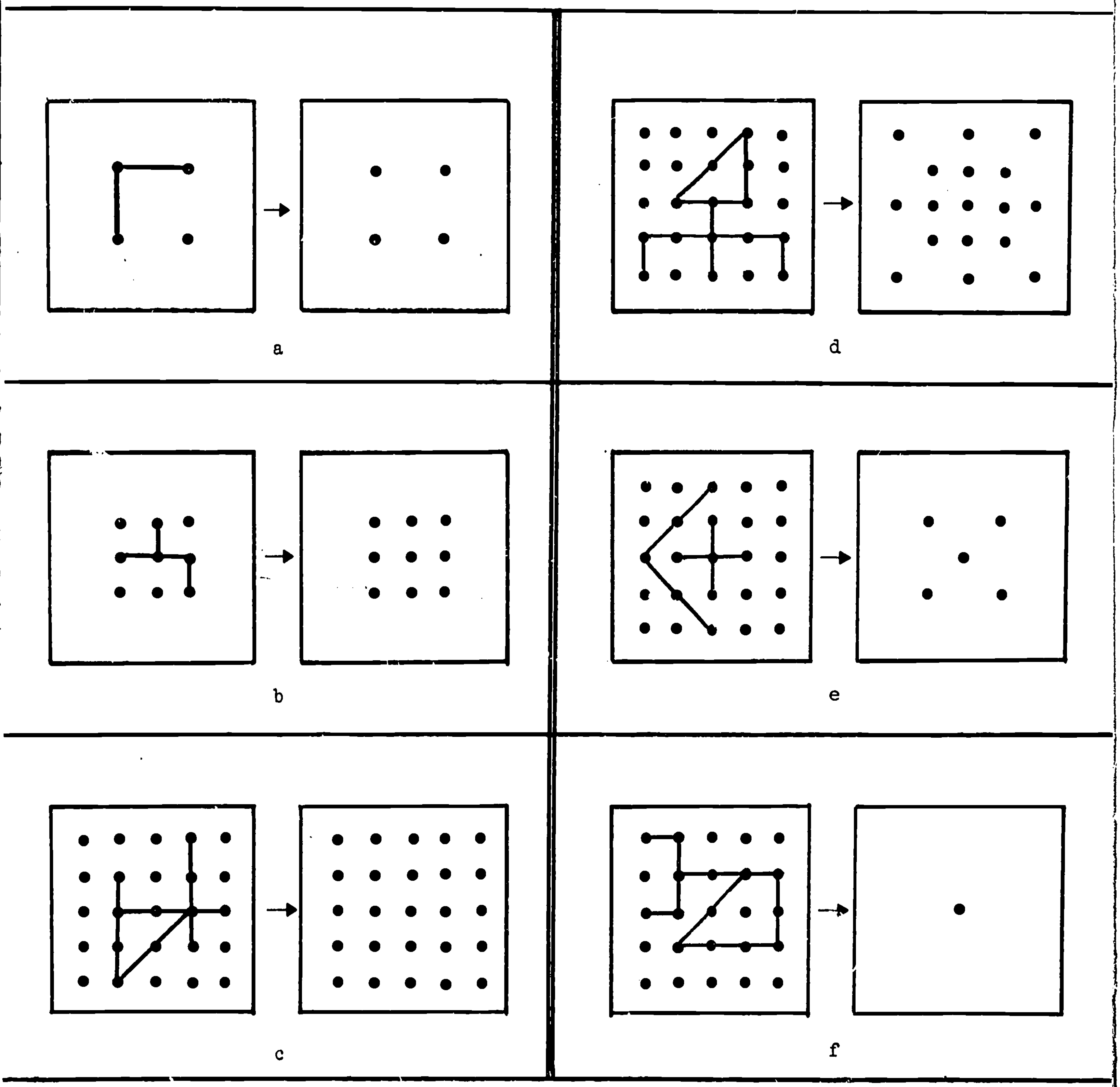
The rationale of the visual-motor curriculum makes the assumption that the ability to copy geometric designs may be considered a valid predictor of general visual-motor development because it demonstrates that the copier has learned certain basic skills: (1) To discriminate the individual graphic elements--the lines--that combine to form the design, (2) to plot the spatial interrelationships of these elements and (3) to apply mapping rules so that the elements and their interrelationships may be reproduced on a blank space.

To teach these basic skills, the child is led through a series of training experiences using a number of manipulative devices. One device, the Design Board (Rosner, 1971), is used throughout the various levels of the visual-motor curriculum. A program of activities has been developed for use with it. The program is based on the premise 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. It is assumed, further, that the complexity of that implicit matrix increases and spatial localizations become more precise as the child matures.

At the lowest level of the training program, very simple designs, drawn on a printed 2 x 2 matrix of dots, are presented to the child. He reproduces the designs by stretching rubber bands on a peg board; the pegs of that board are arranged as a matrix that matches the printed one. As skills are acquired, additional coordinates (rows and columns of dots) are added to the matrix, more complex drawn designs are presented, and the peg board and rubber bands are replaced by a second, matching printed matrix upon which the child draws his reproduction. Finally, the coordinates of the printed matrix on which the child draws his reproductions are gradually eliminated and he is taught to "imagine" their presence. That is, he is taught to view and copy the design <u>as though</u> the coordinates of the matrix were present.

Figure 1 shows six representative levels of the program. Pattern 1-a illustrates a lower level activity. Pattern 1-f is representative

Figure 1: Representative Levels of Design Board Program



of one of the terminal objectives in which the child is asked to draw the stimulus pattern (shown to the left) in a response square that contains one dot only (shown to the right). His task, at this level, is to reproduce the stimulus pattern without the overt support of the full matrix of dots.

The training program's objectives are not designed to teach the child to draw specific geometric designs. Rather, they are designed to teach visual analysis and synthesis skills: visual-motor behaviors that may be generalized to a variety of situations, including the copying of designs.

The visual-motor curriculum contains over 30 behavioral objectives for which criterion-referenced tests have been constructed. For the purposes of this study, twenty-seven of these were treated as test items, and combined into a single copying test known as the Visual Analysis Test (VAT). The questions posed in this study are:

1. Can a reliable method be developed for scoring the test?
2. Do test scores indicate a range of individual differences within and between defined age groups?
3. To what extent do VAT scores correlate with scores from a standardized, norm-referenced copying test? That is, with what degree of validity can one use the VAT score to predict a child's performance on a norm-referenced copying test?
4. Will improvement in VAT scores, effected by treating the test items of the VAT as behavioral objectives and training to them, be reflected in performance on a norm-referenced copying test?

5. What information does analysis of item difficulty provide concerning the hierarchy of the behavioral objectives as represented by the twenty-seven VAT patterns.

METHOD

Subjects

The subjects were all of the available children (N = 667) in grades K through 2, enrolled in two public and one parochial elementary school of a suburban community in Western Pennsylvania.

Procedure

Each child was given the two copying tests described below. In each instance, the Rutgers Drawing Test was administered first, followed immediately by the VAT.

Rutgers Drawing Test - This is a standardized, norm-referenced copying test. Form A is applicable with children ranging from age 4.0 to 7.0; it was used in testing all of the kindergarten and first-grade children in this study. Form B is applicable with children ranging in age from 6.0 to 10.0 and was used for testing the second-grade children. The test provides a three point scoring scale (0, 1, or 2 points for each item). Form A presents fourteen geometric designs to be copied; hence a maximum score of 28 can be achieved. Form B contains sixteen designs.

Visual Analysis Test - The VAT is made up of twenty-seven items. Three items are printed on each 8 1/2 x 11 inch page of the test booklet.

These are shown, reduced to less than 1/6 actual size, in Figure 2. Each of the first eighteen items contains a stimulus: a pattern of lines drawn on a matrix of dots contained within a 2 1/2 inch square; and a response space: a second square of the same size and containing a matching dot matrix. The child is given a pencil with eraser and told to "make this (Examiner [_E_] points to response space) look just like this." (_E_ points to stimulus.) "Draw lines on this (_E_ points) so that it looks just like this." (_E_ points.) The last nine items are somewhat different in that the dot matrix in the response space is incomplete. The response space matrices in items 19, 20 and 21 contain seventeen symmetrically placed dots rather than the full twenty-five. Dots are gradually faded from the matrix until, in item 27, none are shown in the response space. The child is told "Draw your lines in here (_E_ points) so they look the same as these." (_E_ points.) "There are some dots missing." (For item 27, this sentence is changed to "All of the dots are missing.") "Don't draw the dots, imagine (or pretend) they are there." "Just draw the lines."

Inspection of the test items shown in Figure 2 reveals that they are differentiated by a number of factors:

1. The matrices containing the stimulus patterns vary from four dots (items 1, 7), to five dots (items 2, 8), to nine dots (items 3, 4, 9, 10) to twenty-five dots (items 5, 6, and 11 through 27).
2. Twenty patterns contain diagonal lines. These are items 7 through 27, with the exception of items 19 and 20. Three

Figure 2: VAT Items (reduced to less than 1/6 actual size)

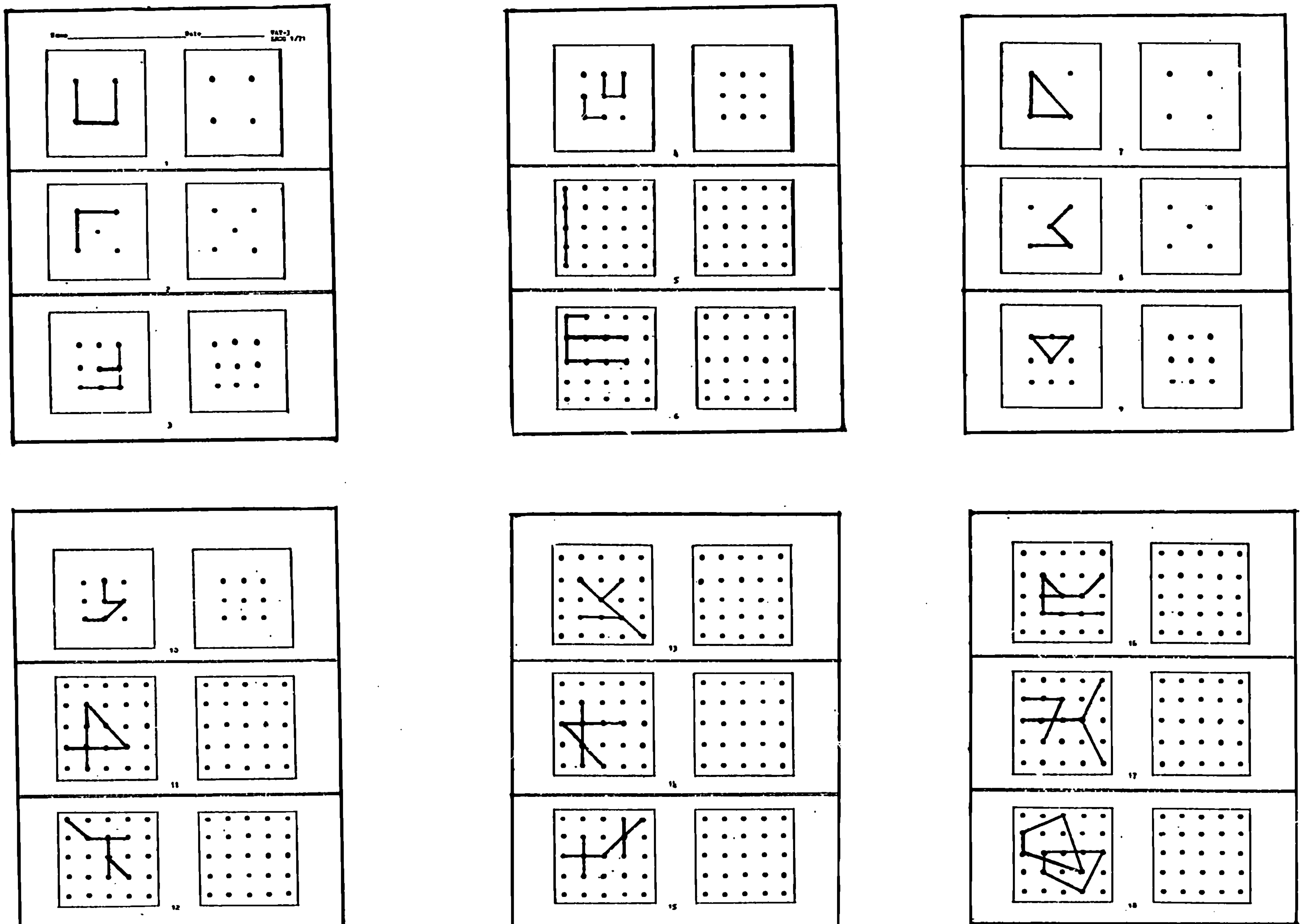
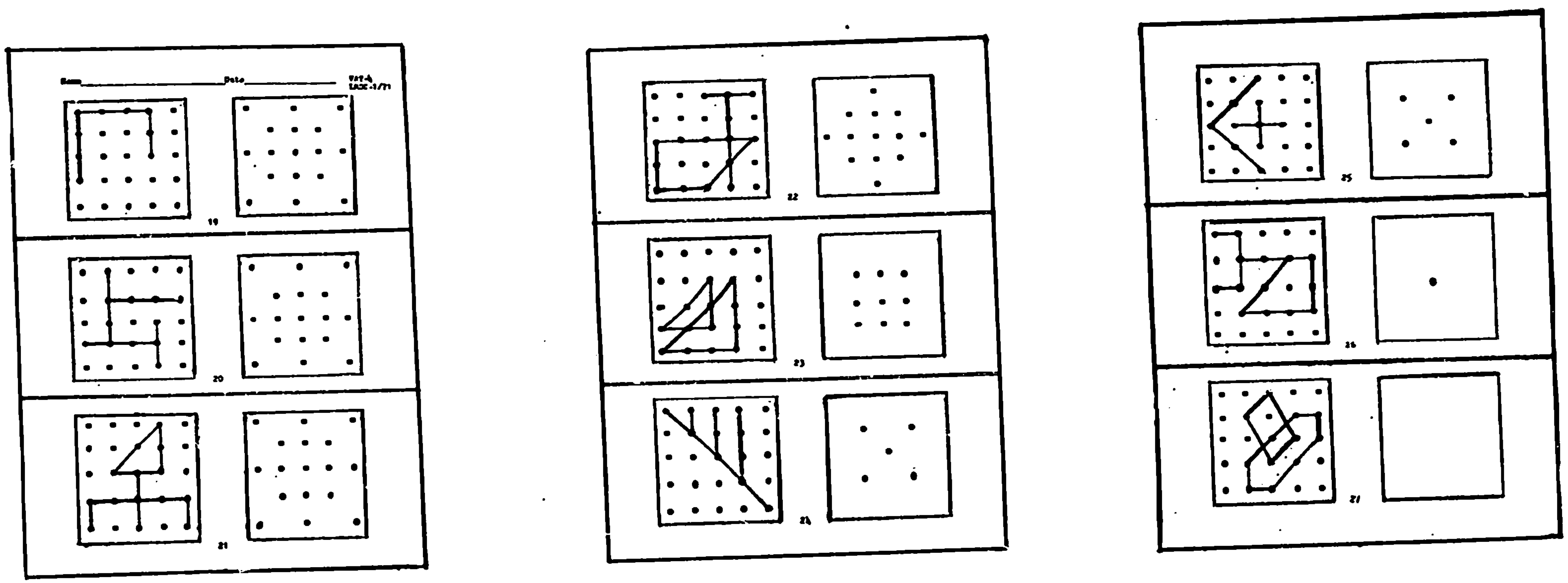


Figure 2 (continued): VAT Items (reduced to less than 1/6 actual size)



of these contain diagonals that connect dots that are not in adjacent rows or columns (items 17, 18 and 27).

3. Eight patterns are constructed of a continuous line that crosses over itself and/or more than one continuous line (items 3, 4, 6, 11 through 18, and 20 through 27).
4. In three items, eight dots have been eliminated from the response matrix (items 19, 20 and 21).
5. In six items, twelve or more dots have been eliminated from the response matrix (items 22 through 27).

Scoring the VAT

To achieve reliability in scoring the VAT, transparencies that show the response matrix and outline the proposed paths in which the subject's lines are to be drawn were prepared for all items. The scorer superimposes the appropriate transparency over the child's response, using the dots and the drawn perimeter of the response space as reference points. A 1/4" path, arbitrarily determined (1/8" on each side of a projected straight line that connects two terminal dots) to contain the child's drawn lines, appears on each transparency. A score of 2 is credited if all of the drawn lines fit within the paths. Should any of the child's drawn lines touch or extend beyond the borders of the path (on the transparency), 1 point is credited, so long as the correct terminal points of the matrix are connected. Connecting the wrong terminal points or omitting a line results in a score of "0" for that item. A minimum inter-rater reliability of .98 was established between three project staff members scoring independently, indicating a very satisfactory and reliable scoring method.

RESULTS

Table 1 shows the mean and median VAT scores for the kindergarten, first- and second-grade groups included in this study. These are organized according to school as well as grade. The range of scores within and between each group, as may be noted, is fairly broad. The kindergarten's mean VAT scores range from a low of 16.2 in School C to a high of 20.6 in School A. The class mean VAT scores in first grade are distributed from 31.0 to 33.4. Second-graders showed even larger intra-grade differences. Their mean scores ranged between 34.3 to 41.2.

Table 1

VAT Mean, Median and Range of Scores for
Kindergarten, Grades 1 and 2

Grade	School	N	VAT $\bar{X}$	S.D.	Median	Range
K	A	94	20.6	9.3	20	2-47
	B	--	--	--	--	--
	C	161	16.2	8.7	16	0-42
1	A	83	33.4	7.7	34	15-48
	B	59	33.5	8.8	36	10-48
	C	73	31.0	9.9	32	7-48
2	A	74	41.2	6.1	42	24-52
	B	45	38.2	6.5	38	23-49
	C	78	34.3	8.2	35	13-49

To establish the relationship between a VAT score and performance on a standardized, norm-referenced copying test, a Pearson product moment correlation coefficient was calculated for all of those taking both the VAT and the Form A Rutgers Drawing Test (N = 470). A correlation coefficient was also calculated for those in second grade who took both the VAT and Form B of the Rutgers Drawing Test (N = 197). In both instances, the correlation coefficients are positive and high; with Form A Rutgers, $r = .80$; with Form B, $r = .68$. Hence, the VAT accounted for 64 percent of the variance in the Form A scores and 46 percent of the variance in Form B scores of the subjects in this study.

DISCUSSION

The VAT seems to provide a systematic method of assessing the degree to which a child has learned to reproduce graphic patterns on matrices that range from full and precise replications of the ones that support the stimulus pattern, to those that replicate the matrix of the stimulus in diminishing amounts. The scoring method used in this study provided a simple yet remarkably reliable method for quantifying copying responses. The high inter-rater reliability that was shown is indicative of the exceptionally low incidence of scoring situations that force one to base his judgment on unstated or conflicting criteria--a problem not unfamiliar to those who have attempted to score copying tests. Hence, an affirmative response is provided to the first question of this study. A reliable scoring scale is indeed available.

Question 2 concerned the test's ability to determine individual differences in copying skills. A range of differences within and between groups is clearly apparent. All the schools included in this study show the same pattern of lowest scores attributable to the youngest children and the highest scores to the oldest children, thus attesting to the developmental nature of the task. Broad inter-class differences also were shown at all three age levels. This, of course, is not explainable in terms of chronological age; it appears, rather, to be related more closely to other factors.

The third question, relevant to that percentage of the variance evidenced in a standardized, norm-referenced copying test that could be accounted for by the VAT, may also be discussed on the basis of the data presented above. A highly significant positive correlation was shown between the VAT and the Rutgers (Form A) as used with the kindergarten and first-grade children. A significant, though not as high, correlation was also shown between the VAT and the Rutgers (Form B). To explore this topic further, Expectancy Tables were constructed for both the A and B forms of the Rutgers, as predicted by the VAT scores. The strong positive relationship between VAT scores and the Rutgers A is apparent in Table 2. Among the 136 children (approximately 29 percent of total N) who scored less than 17 on the VAT, only 6 (or approximately 4.4 percent) scored higher than 20 on the Rutgers Form A. The pattern is consistent in that among the 132 children who scored higher than 32 on the VAT, only 4 scored less than 16 on the Rutgers, Form A. Table 3

represents the data of the second-graders who were tested with both the VAT and Form B of the Rutgers. This table, too, seems to demonstrate the predictive validity of the VAT to a norm-referenced copying test, although the relationship is not as tight as with the younger group.

Table 2

Expectancy Table Showing the Relation Between Scores on the VAT and Rutgers Drawing Test, Form A

VAT Scores	N	Percentage Scoring in Each Interval of Rutgers A						
		0-4	5-8	9-12	13-16	17-20	21-24	25-28
45-48	14	0	0	0	0	0	29	71
41-44	32	0	0	0	0	3	31	66
37-40	33	0	0	0	0	21	36	43
33-36	53	0	0	0	4	15	55	26
29-32	45	0	0	0	9	44	36	11
25-28	54	0	0	0	9	50	35	6
21-24	54	0	0	7	39	32	22	0
17-20	52	0	0	15	37	35	13	0
13-16	52	0	0	17	37	40	6	0
9-12	31	3	3	37	41	16	0	0
5-8	38	0	26	40	29	5	0	0
0-4	15	20	47	33	0	0	0	0

Table 3

Expectancy Table Showing the Relation Between Scores on the VAT and Rutgers Drawing Test, Form B

VAT Scores	N	Percentage Scoring in Each Interval of Rutgers B							
		0-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32
49-52	15	0	0	0	0	0	7	60	33
45-48	36	0	0	0	3	5	25	50	17
41-44	53	0	0	0	0	25	42	28	5
37-40	43	0	2	0	12	33	33	18	2
33-36	34	0	0	6	29	18	35	12	0
29-32	21	0	0	24	14	48	14	0	0
25-28	15	0	0	13	60	20	7	0	0
21-24	8	0	0	25	38	0	25	12	0
17-20	3	0	67	33	0	0	0	0	0
13-16	1	0	0	100	0	0	0	0	0

In dealing with the fourth question of this study which concerns the relationship between improved VAT scores, as the result of training, and norm-referenced test scores, we can examine some earlier reported data. Two studies are pertinent. In one (Rosner, Levine & Simon, 1970) it was reported that Design Board training with a group of kindergarten children was directly related to significant changes in the Geometric Design Subtest of the WPPSI (Wechsler, 1967). This subtest asks for the

copying of designs of varying complexity. In another study (Rosner, 1970), strong support was given to the hypothesis that preschool children's copying skills, as measured by the Rutgers Drawing Test, were improved significantly after a period of Design Board training. Inasmuch as the items of the VAT represent behavioral objectives of the Design Board program, it seems reasonable to suggest that, indeed, improvement in the VAT score as a result of training will be reflected in the Rutgers Drawing Test scores as well.

The last question to be explored concerns an analysis of item difficulty as one way to determine the hierarchy of behavioral objectives as represented by those 27 items. Table 4 shows the rank order of item difficulty and the percentage of correct responses according to grade. They are ordered from easiest to most difficult.

Inspection of those data suggests that use of items beyond number 18 in kindergarten is of little value insofar as discriminating between children. The items are clearly too difficult. The same effects, for opposite reasons, are noted on most of the first nine items of the VAT with grades 1 and 2. In most instances, they are too easy.

It seems, also, that certain generalizations may be made about those factors that differentiate the easier from the more difficult items. Although the data do not support precise categorizations, it seems reasonable to mention certain criteria that appear to affect directly the relative difficulty of the items. These are:

1. The easiest items are those three (items 1, 2, 5) that are constructed of continuous lines (i.e., do not require the

Table 4

Percentage of Correct Item Responses Arranged in Order of Increasing Difficulty, According to Grade

	KINDERGARTEN		GRADE 1		GRADE 2	
Rank	Item Number	% of correct responses	Item Number	% of correct responses	Item Number	% of correct responses
1	5	74.6	1	90.7	2	94.9
2	1	70.0	2	90.2	5	90.9
3	2	67.2	5	89.3	1	90.4
4	8	62.5	10	89.3	10	88.4
5	4	59.8	4	87.5	4	87.4
6	3	52.3	8	86.5	8	85.9
7	10	50.4	3	82.3	9	84.3
8	6	46.5	7	80.5	7	82.3
9	7	43.4	9	79.5	3	81.8
10	9	43.0	6	77.7	6	79.3
11	12	33.2	13	66.9	12	76.3
12	15	27.7	12	66.0	13	70.7
13	14	24.2	15	59.1	19	69.7
14	13	22.7	14	58.1	15	69.2
15	11	20.3	11	57.2	11	67.2
16	16	17.2	16	53.5	14	65.2
17	17	12.1	17	44.2	16	63.1
18	19	6.6	19	42.3	21	58.6
19	20	3.9	20	40.5	20	58.1
20	21	3.1	21	38.6	17	55.6
21	18	2.3	22	22.3	22	36.9
22	22	2.0	18	18.1	23	34.8
23	25	1.6	23	13.9	18	28.3
24	24	0.8	24	6.0	24	27.3
25	23	0.4	25	5.6	25	12.1
26	26	0.0	26	5.6	26	9.6
27	27	0.0	27	0.0	27	0.5

lifting of the pencil, although vertical and/or horizontal directional changes occur). It is interesting to note that one of the three is plotted on a full matrix of twenty-five dots. In fact, this one was easiest of all for the kindergarten children.

2. The next group, in order of increasing difficulty, are those seven items (3, 4, 6, 7, 8, 9, 10) that either contain one or more diagonal lines or are constructed of more than one continuous line. Hence, the child must localize at least two starting points on the matrix. All but one of these (item 6) are plotted on matrices of less than twenty-five dots.
3. The third group (items 11, 12, 13, 14, 15, 16) are all plotted on full, twenty-five dot matrices. All are constructed of multi-directional lines that intersect at least once.
4. The next more difficult group consists of only one item (17). This construction is much like those of the preceding group with one critical difference. It contains diagonal lines that connect dots that are not in immediately adjacent rows or columns.
5. The fifth group appear to be those items (19, 20, 21) that require the subject to draw his response on an incomplete matrix; one from which eight dots have been eliminated. The stimulus patterns of this group are not particularly

complex; they meet the description of group 3, described above. Item 19, for example, was appreciably easier for the second-grade group than for the younger children. In this older population, it ranked as substantially easier than most of the items of Group 3.

6. The sixth group is yet another that appears to contain only one item (18). It is distinctive in that it is constructed of two interlocking polygons and contains five diagonal lines that join non-adjacent points. It was a difficult item for all the children.
7. The last group includes those items (22 through 27) that provide response matrices where twelve or more dots have been eliminated.

The Perceptual Skills Curriculum is based on the Primary Education Project model (Resnick, 1967). As such, desired terminal behaviors are identified and stated. The supportive behaviors, identified by component analysis of the terminal tasks, are also stated and ordered in a hierarchical sequence. Criterion-referenced tests are written for all objectives in behavioral terms. Hence, given a valid hierarchy of skills, one may test at strategic points in the sequence to determine where instruction should begin. The data derived from the analysis of item difficulty, therefore, are particularly useful for such an approach.

Clearly there are gaps within the scaling of the twenty-seven items. No single criterion, be it stimulus matrix size, completeness of response matrix or complexity of drawn pattern, can be used to

predict difficulty of the task. It is in the interrelationships of these three that such a scaling is determined. Although the groupings proposed above are sufficiently precise to meet the needs of the curriculum development at this time, they should be refined further. If the rationale of visual-motor development upon which this approach is based is correct, a precise statement of the criteria from which items may be scaled should enable one to assess an important aspect of child development in a highly reliable fashion.

Conclusions

Visual-motor skills provide insight into one aspect of a child's maturation. There appears to be a direct relationship between the child's acquisition of precise visual analysis skills and his general growth and development. The VAT provides a method for evaluating quantitatively a 5- to 7-year-old child's ability to analyze increasingly complex visual patterns. The data also tend to support speculation that the VAT will be useful with children somewhat younger than 5 and older than 7. Additional studies are needed to support that hypothesis, however.

The test appears to have predictive validity to norm-referenced visual-motor instruments. It also appears to be sampling a generalizable function in that the test items may be used as instructional objectives without invalidating the predictive power of the test. On the contrary, treating the VAT items as teaching objectives may be done with a reasonable expectation that acquiring competency in the behaviors they represent will, in fact, be generalized to other related tasks.

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