Visual-motor Skills: Response Characteristics and Pre-reading Behavior

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Assumed facets of kindergarten subjects' visual-motor skill were studied by an analysis of the interrelationships in response characteristics to a set of geometric forms. Implications for initial response to letterforms (reading readiness) is discussed. Two measures of intersensory equivalence were used with the stimulus perceived through the sense of active touch (haptics). Stimulus characteristics—contour, closure, size, rotation, and embeddedness—were varied in five visual-discrimination subtests. Kindergarten subjects' V-M skill is significantly related to achievement in intersensory equivalences and in visual discrimination of geometric forms.

For some time, young children's ability to copy geometric forms has been used as an index to their perceptual development. The developmental norms, in reference to mental age, which have been accepted generally are as follows: (a) age 3, the circle and vertical cross, (b) age 5, the square and triangle, (c) age 6, the diagonal cross, and (d) age 7 or 8, the vertical diamond, horizontal diamond, and divided rectangle. After 8 years of age, children's extreme distortions in copying tend to have pathological significance. Before this time, the implications of distortions have not been elaborated. In addition, the non-comparability of scoring criteria and, therefore, of acceptable reproductions appear to limit the functional use of these norms for assessing visual-motor skill (see Table I).

Visual-motor skill, as defined in the present research, refers to the copying of outline forms by young children. It includes—in terms of learning behavior—a visually perceived stimulus, intersensory mediation, and a motor response. Therefore, the quality of the response may be affected by immaturity in perceiving visually, immaturity in motor response, or integrative difficulties in the central nervous system.

Consequently, a valid interpretation of children's copying ability

TABLE I. *Visual-Motor Development: Normative Data*

Investigator or Source	*1*	*2*	*3*	*4*	*5*	*6*	*7*
				Age of Subjects			
Bender (1938)	Scribbling		Differentiated into loops		Rapid differentiation, dextral and horizontal directions first. Patterns organized		
Gesell, and Others (1940)	Scribbles spontaneously	Vertical line	Horizontal stroke Copies circle, vertical cross	—	Copies square, triangle divided rectangle	Copies diamond	—
Terman and Merrill (1937)			Copies cross, circle	—	Copies square, triangle	—	Copies diamond
Vernon (1963)							Copies interior of divided rectangle correctly
Piaget and Inhelder (1963)	*Stage 0* Scribbles with no variation		*Stage 1* Scribbles vary according to model Closed and open shapes distinguished Square and triangles *not* distinguished from circles	*Stage 2* Square sep. from triangle Circle sep. from ellipse		*Stage 3* Rhombus drawn correctly	All problems overcome geometric shapes easier to draw than natural figures

seems to have implications as one criterion for perceptual reading readiness. The perceptual facet of reading appears to be a major factor in effective reading instruction and a primary problem in most clinical cases. Although the complexities of orthography are beyond the scope of this investigation, certain generalizations may apply to letterforms in the sense that they are interpreted as two-dimensional outline drawings. In other words, veridical pattern perception (e.g., b vs. d) becomes a critical factor as a child approaches school age.

The *criterial* stimulus attributes of letters and letter sequences as discriminated geometric forms include perceived differences in contour, closure, rotation, size, and embeddedness. An arbitrary division of these attributes renders the situation somewhat artificial. However, illustrations may be given in which each seems to be a dominant factor.

Discriminations in contour may be illustrated, for example, by i vs. c, v vs. u, home vs. come. When a child can take the -at from cat and apply it to sat, he is evidencing one type of closure. He discriminates differences in closure in c vs. o. Size is incorporated in the discrimination of BANG from bang, although there are also differences in contour. Size is also a factor in c vs. C, u vs. U, n vs. h. Rotation is the critical component in b, p, d, q, and in u vs. n. Embeddedness of go in going is but one example of this kind of discrimination.

The first purpose of the present investigation deals with possible cognitive-set effects on the reproductions in the visual-motor test. In other words, does the child's concept of a geometric form contribute to his ability to copy it? The effects of selective attention on a perceptual task have been modified by the different ways in which the subjects encoded the stimulus [18, 20].* Furthermore, the effects of verbal labels on cognitive set have modified reproductions and responses of subjects [7, 9]. In the case of ambiguous stimuli, perceptual set appears to be mediated by a class concept, e.g., letters presented prior to a broken-B stimulus [6]. Under similar conditions, perceptual-set deficiency has been attributed to young children 3 to 5 years of age [23, 33].

* Figures in brackets refer to references which begin on page 180.

TABLE II. *Haptic-Visual Equivalences and Stages in Haptic (Tactile) Explorations*

	Age of Subjects							
Investigator	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Piaget and Inhelder (1963) (Haptic perception)	*Stage 0* Experimentation not possible		*Stage 1* Familiar objects easily recognized, but not euclidian figures		*Stage 2* Euclidian figures progressively differentiated		*Stage 3* Synthesis of complex forms achieved	
Birch and Lefford (1963) (Intersensory discrimination)					Equate haptic-visual information		Period of rapid change in functional organization—Visual-haptic integration achieved	
Zaporozhets (1965) (Tactile explorations)			Movements more like catching than touching	Movements similar with new elements Catching with 4 fingers and palm				
				Used palms and surfaces of fingers—Tactile exploration with 1 hand	Simultaneous touching of figure		Systematic tracing of whole outline of figure with fingertips	
Fisher (1965) (Haptic perception)		Passive touch No tactile exploration		Detailed tactile examination Identified majority of 30 common objects (e.g., banana, penny)				
					Linear shapes identified as readily as topological shapes (Taught nonsense names)			

Reported normative data and theoretical positions regarding the development of visual-motor skills are relevant to the second purpose of the present study—the range of children's achievement in copying certain geometric forms. Copying behavior has been assumed to reflect a learned type of form perception [17, 29]. Moreover, the correlation of copying with form perception, .60, has been reported significantly higher than that of copying with any motor ability, .00 to .18 [37].

A study of response implications in a visual-motor task may be facilitated by considering the implications of intersensory achievement—the third purpose of the present study. The assumptions are: (a) if experiences in other modalities have contributed to perceptual learning, and (b) if inferences about the level of perceptual achievement can be made from the drawings of children, then (c) a concurrent investigation of intermodal equivalences with the same set of geometric forms may contribute to certain insights. For example, is the achievement of a five-year-old higher for haptic-visual equivalences (forms explored by means of active touch and matched with a visual stimulus) or for haptic-kinesthetic equivalences (forms explored by means of active touch and then drawn without "seeing" the stimulus)? Sensory inputs through other modalities that are "perceived" appear to be mediated by a visual image of the stimulus.

The research on intermodal discrimination is extremely limited [22, 27]. Moreover, the hierarchical hypothesis of perceptual development has not been supported by the research evidence [31]. However, there are developmental changes in intersensory equivalence. Visual-haptic equivalences were achieved readily by five-year-olds, but visual-kinesthetic and haptic-kinesthetic equivalences were poorly integrated. A minimum of errors occurred under all conditions by 11 years of age [3] (see Table II).

Inferences about visual-motor skill also may be modified by a study of the relationships among five factors in visual-discrimination achievement and the *quality* of a reproduction in a copying task with the same set of geometric forms. For example, if a child drew a cross considerably smaller than the stimulus in the visual-motor task, yet could discriminate accurately the size of the same form in a visual-discrimination task, then inferences about the size of his drawing would not seem valid at his stage of development. Since letters in terms of their physical properties are geometric forms, the five previously mentioned *criterial* attributes—contour, closure, rotation, size, and embeddedness—of letter sequences were categorized in regard to distortions in children's copying ability and in a series of visual-discrimination tasks. These relationships were subsequently analyzed.

Contour bounds a figure, and shape can be considered a derivative of contour [10]. Conflicting data have been reported as to young children's ($3\frac{1}{2}$ to 7 years) utilization of contour cues. However, the upper contour of a figure appears to gain importance with subjects' increasing age [5, 24].

In perception, closure may refer to the preference for closed organization of stimuli or to the tendency of the organism to complete partial stimulus presentations [4, 38]. Ability to effect closure in reading may refer to an integrative process of completing perceptually a word stimulus in which a part was previously unknown [2].

Studies of size constancy as a function of subjects' age have yielded inconsistent data, but there is evidence that constancy increases with subjects' age [8, 29]. Kindergarten subjects were almost as accurate as adults in size judgments of similar-shaped geometric forms, but displayed greater variability [14]. Size constancy has been reported as reaching adult level at 9 to 10 years of age [29].

Despite variations in experimental design and in findings, the evidence is overwhelming that young children have difficulty with the spatial orientation of stimuli and perceive vertical reversals more easily than horizontal reversals [16, 35].

In addition, children from 4 to 7 years have difficulty in perceiving embedded figures, i.e., not clearly set apart [15, 40]. Even at 8 years of age, they make more errors than adults [39]. However, conflicting data have been reported for overlapping shapes. Children experience difficulty with this task before 5 to 6 years of age [30], yet four-year-olds have shown a high level of performance for overlapping figures [15].

Another consideration is the predictive indices which may be obtained from perceptual measures. In beginning reading, for example, predictive tests should permit valid inferences regarding entering behavior in the perceptual facet of the reading process. Although the studies in this category remain largely exploratory, the bulk of the evidence points up a significant relationship between measures of visual discrimination or visual-motor skill and a standardized criterion of reading achievement [1, 19, 32]. However, as Koppitz [25] has pointed out, the scoring systems used by various investigators do not render their findings comparable.

The Problem

The investigation was undertaken to study (a) assumed facets of kindergarten subjects' visual-motor skills and (b) the relationship between achievement in these skills and a measure of visual-perceptual reading readiness. Data were obtained to test six hypotheses in null form:

*H*1: There is no significant relationship between kindergarten subjects' concepts of geometric forms and their ability to reproduce these forms by copying.

*H*2: There are no significant differences in kindergarten subjects' ability to copy the eight stimulus geometric forms.

*H*3: There are no significant relationships among visual, haptic, and kinesthetic equivalences.

*H*4: There are no significant relationships among visual-discrimination abilities in terms of the stimulus characteristics of the geometric forms.

*H*5: There are no significant relationships between achievement in the visual-motor test and certain measures of perception.

*H*6: There are no significant relationships between achievement in the word-discrimination test and certain measures of perception.

TABLE III. *Intercorrelations Among All Test Variables* ($N=58$)

Test	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1. Word discrimin.	—	.20	.29	.13	.16	.21	.28	.43	.43	.38	.39	.53
2. Visual motor	.20	—	.02	.35	.27	.39	.09	.29	.16	.19	.33	.33
3. Con. of draw.	.29	.02	—	.18	.18	.27	.38	.40	.06	.42	.18	.38
4. Haptic-visual	.13	.35	.18	—	.38	.81	.11	.29	−.19	.18	.23	.21
5. Haptic-kinesth.	.16	.27	.18	.38	—	.80	.04	.18	−.12	.22	.10	.13
6. Hapt.-vis.-kin.	.21	.39	.27	.81	.80	—	.13	.33	−.15	.30	.24	.27
7. Contour	.28	.09	.38	.11	.04	.13	—	.65	.08	.48	.27	.64
8. Closure	.43	.29	.40	.29	.18	.33	.65	—	.22	.64	.43	.80
9. Size	.43	.16	.06	−.19	−.12	−.15	.08	.22	—	.26	.24	.44
10. Rotation	.38	.19	.42	.18	.22	.30	.48	.64	.26	—	.48	.79
11. Embeddedness	.39	.33	.18	.23	.10	.24	.28	.43	.24	.48	—	.80
12. Visual discrim.	.53	.33	.38	.21	.13	.27	.64	.80	.44	.79	.80	—

Note: Correlations of .25 significant at .05 level and .33 significant at .01 level.

Procedures

A series of three tests—a visual-motor, a visual-haptic-kinesthetic, and a visual-discrimination test—was developed with the same set of geometric forms. The second two tests varied sensory modalities and stimulus characteristics. The visual-motor test was adapted from the CVAF (Lions Club of Winter Haven) with one figure added, making a total of eight forms—a circle, vertical cross, diagonal cross, square, triangle, vertical diamond, horizontal diamond, and divided rectangle. A scoring procedure was devised and evaluated regarding specific response deviations (e.g., rotation) in reproducing these forms.

A preliminary study with 31 kindergarten subjects was conducted to validate these tests and to standardize test procedures and directions. An interscorer coefficient of agreement (.71 for individual forms and .96 for total score) was computed for the visual-motor test, and the scoring procedure was submitted to a panel of advisers. Difficulty and discrimination indices were computed for the multiple-choice, visual-discrimination test; ineffective test items were revised or omitted.

In the subsequent main investigation, the three tests, a test of finger agnosia, and two standardized measures—the *Lorge-Thorndike Intelligence Test*, Level I, Form A, and the Word-Form Test of the *Betts Ready-to-Read Tests*, V-2—were administered individually by the investigator (with considerations for test interaction and practice effects) to 58 kindergarten subjects, who had been selected by random sampling from the total kindergarten population of three schools.

An intrascorer coefficient of agreement (.93) was obtained for the visual-motor test, and Kuder-Richardson Formula #21 was used to compute the reliability (.83) of the objective measures. In addition, photographic translucencies were made according to objective criteria for scoring borderline deviations in the visual-motor test. Interrelationships of subtests and tests were obtained by product-moment coefficients of correlation, which were converted to zr's to test significance (see Table I). In addition, the protocols for each test were analyzed for related data.

Results

Of the six null hypotheses, the first was accepted and the others were rejected. The findings may be summarized as follows:

1. The relationship between kindergarten subjects' concepts of geometric forms and their ability to copy them was not significant.

2. The subjects' scores for copying geometric forms ranged from no response distortions (5) to inability to reproduce the form (0). Their highest achievement was with the vertical cross and the lowest, with the divided rectangle.

3. The relationships among visual, haptic, and kinesthetic equivalences were all significant beyond the .01 level.

4. Twelve of fifteen relationships among visual-discrimination abilities were significant; two were at the .05 level and the rest, beyond the .01 level.

5. Six of eleven relationships between the visual-motor test and other perceptual measures were significant; one was at the .05 level and the remainder, beyond the .01 level.

6. Seven of eleven relationships between the word-discrimination test and other perceptual measures were significant; two were at the .05 level and the others, beyond the .01 level.

Discussion

The visual-motor behavior of young subjects is important in the educational sense to the extent that it reveals (a) an identifiable level of this type of perceptual achievement, (b) valid inferences regarding probable perceptual needs (e.g., a subject's inability to perceive rotation of a form), (c) a significant relationship to the perceptual facet of reading behavior, and (d) possible implications for improving perceptual abilities.

Almost all of the subjects who did not achieve at a high level in word discrimination—the measure of visual-perceptual reading readiness—experienced difficulty in reproducing the vertical diamond, horizontal diamond, and divided rectangle in the visual-motor task. They tended to make either poor or unscorable (score 0) reproductions. On the other hand, good to superior achievers in word discrimination rarely made unscorable reproductions of these three forms and were somewhat less likely to make poor ones. It appears, therefore, that certain forms have discriminating potential as rapid screening devices for pupils who may experience perceptual difficulty in reading.

In addition, the fifth year of a child's life appears to be one of substantial individual differences in visual-motor skill and suggests vastly different types of entering behaviors in achievement. A logical inference seems to be that perceptual training with geometric forms, at a child's instructional level, probably would facilitate visual-motor skill and possibly improve perceptual abilities. This type of training would seem to be of particular value to the child who is not yet able to cope with the geometric attributes of letter-symbol sequences.

In relation to possible cognitive-set effects assessed subsequent to reproduction, a kindergarten subject's concept of a form as belonging to a class (e.g., square) does not appear related to his skill in reproducing the form. However, factors in concept attainment—defining the attributes of a class (e.g., four equal sides, right angles)—may be related to this skill. Furthermore, since the forms which were most "difficult" for the subjects to reproduce tended to evoke the greatest diversity of concepts (including "I don't know"), the factor of past experience is suggested as a variable in visual-motor skill.

In addition, measures of intersensory equivalence appeared to yield some insights regarding visual-motor skill. Except for the circle with which the great majority of subjects achieved both haptic-visual and haptic-kinesthetic equivalences, there was a differential order of geometric-form achievement between the two types of intersensory equivalence and between each type (i.e., haptic-visual and haptic kinesthetic) and the visual-motor task. This finding suggests that the order of stimulus "difficulty" may be a function of modalities as well as the properties of the stimulus (e.g., complexity).

Furthermore, since haptic-visual equivalences tended to be achieved more readily than haptic-kinesthetic equivalences, the implication is that mediation of the visual image tends to be achieved more readily than the motor pattern. For example, a substantial majority of subjects achieved the visual image for the vertical and horizontal diamonds, yet only about one-fourth achieved a kinesthetic equivalence for either form. Although motor ability per se may not be an important factor in visual-motor behavior, as reported in other investigations, achievement of the motor *pattern* is strongly implied by the present findings.

In addition to intersensory equivalences, achievement in visual discrimination of geometric forms was significantly related to visual-motor skill. This type of achievement, although it does not appear to be a unitary ability, is suggested as an important factor in visual-motor behavior. For the present subjects, it appears that response distortions in the visual-motor test cannot be interpreted as the subjects' inability to perceive differences in contour size, and rotation. However, the factor of closure appears to have some implications in reproductions and to merit investigation.

Furthermore, kindergarten subjects' visual-discrimination abilities suggest a differentiated development related to stimulus attributes of geometric forms. Size differences appear to be perceived most easily, then differences in shape or contour (e.g., v vs. u). At about the same level is the ability to perceive differences in rotation or spatial orientation (e.g., b vs. d, p vs. q, u vs. n). Somewhat more difficult, for the present subjects, was perceiving differences in closure (e.g., c vs. o) and in embeddedness. An example is discriminating beet from beat, in which e and a are embedded in similar environments. These findings appear to have implications for a task taxonomy in visual-discrimination tasks for young subjects.

REFERENCES

1. Barrett, T. C. Visual discrimination tasks as predictors of first grade reading achievement, *Reading Teacher*, 1965, *18*, 276–282.
2. Betts, E. A. Excellence in contemporary reading instruction, *New England Reading Association Journal*, 1966, *1*, 5–15.
3. Birch, H. G., and Lefford, A. Intersensory development in children, *Monographs of the Society for Research in Child Development*, 1963, *28*, whole no. 89.
4. Bobbit, J. M. An experimental study of the phenomenon of closure as a threshold function. In C. C. Beardslee and M. Wertheimer (eds.), *Readings in Perception*. New York: Van Nostrand, 1958.

5. Braine, L. G. Age changes in the mode of perceiving geometric forms, *Psychonomic Science*, 1965, *2*, 155–156.

6. Bruner, J. S., and Minturn, A. L. Perceptual identification and perceptual organization, *Journal of General Psychology*, 1955, *53*, 21–28.

7. Bruner, J. S., Buseik, R. D., and Minturn, A. L. Assimilation in the immediate reproduction of visually perceived figures, *Journal of Experimental Psychology*, 1952, *44*, 151–155.

8. Brunswick, E. *Perception and the representative design of psychological experiments*. Los Angeles: University of California Press, 1956.

9. Carmichael, L., Hogan, H. P., and Walter, A. A. An experimental study of the effect of language on the reproduction of visually perceived form, *Journal of Experimental Psychology*, 1932, *15*, 73–86.

10. Deutsch, J. A. A system for shape recognition, *Psychological Review*, 1962, *69*, 492–500.

11. DiMeo, Katherine. *Visual-motor skills: response characteristics and pre-reading behaviour*. Unpublished doctoral dissertation, University of Miami (Miami, 1967).

12. DiMeo, Katherine. *Visual-motor skills: response characteristics and pre-reading behavior*. Winter Haven, Florida: Winter Haven Lions Research Foundation, 1967.

13. Drever, J. Early learning and the perception of space, *American Journal of Psychology*, 1955, *68*, 605–614.

14. Estes, Betsy W. Judgment of size in relation to geometric shape, *Child Development*, 1961, *32*, 277–286.

15. Ghent, Lila. Perception of overlapping and embedded figures by children of different ages, *American Journal of Psychology*, 1956, *69*, 575–587.

16. Ghent, Lila, and Bernstein, L. Influence of the orientation of geometric forms on their recognition by children, *Perceptual and Motor Skills*, 1961, *12*, 95–101.

17. Gibson, Eleanor J. Development of perception: discrimination of depth compared with discrimination of graphic symbols, *Monographs of the Society for Research in Child Development*, 1963, *27*, 5–24.

18. Gibson, J. J. The reproduction of visually perceived forms, *Journal of Experimental Psychology*, 1929, *12*, 1–39.

19. Goins, Jean T. *Visual perceptual abilities and early reading progress*, Supplementary Educational Monographs, No. 87. Chicago: University of Chicago Press, 1958.

20. Haber, R. N. A replication of selective attention and coding in visual perception, *Psychological Review*, 1964, *67*, 402–404.

21. Hermelin, B., and O'Conner, N. Recognition of shapes by normal and subnormal children, *British Journal of Psychology*, 1961, *52*, 281–284.

22. Kelvin, R. P. Discrimination of size by sight and touch, *Quarterly Journal of Experimental Psychology*, 1954, *6*, 23–24.

23. Kendler, T. S., Kendler, H. H., and Wells, D. Reversal and nonreversal shifts in nursery school children, *Journal of Comparative and Physiological Psychology*, 1960, *53*, 83–88.

24. Kerpelman, L. C., and Pollack, R. H. Developmental changes in the location of form discrimination cues, *Perceptual and Motor Skills*, 1964, *19*, 375–382.

25. Keppitz, Elizabeth M. *The Bender-Gestalt test for young children.* New York: Grune & Stratton, 1964.

26. Kuenne, M. R. Experimental investigation of the relation of language to transpositional behavior in young children, *Journal of Experimental Psychology*, 1946, *36*, 471–490.

27. Lobb, H. Vision versus touch in form discrimination, *Canadian Journal of Psychology*, 1965, *19*, 175–187.

28. Peel, E. A. Experimental examination of some of Piaget's schemata concerning children's perception and thinking and a discussion of their educational significance, *British Journal of Educational Psychology*, 1959, *29*, 89–103.

29. Piaget, J., and Inhelder, Barbel. *The child's conception of space.* London: Routledge & Kegan Paul, 1963.

30. Piaget, J., and Stettler-von, A. B. Observations sur la perception des bonnes formes chez l'enfant par actualization des lignes virtuelles, *Archives de Psychologie*, 1954, *34*, 203.

31. Pick, H. L., Jr. Perception in Soviet psychology, *Psychological Bulletin*, 1964, *62*, 21–35.

32. Potter, Muriel C. *Perception of symbol orientation and early reading success*, Contribution to Education, No. 939. New York: Teachers College, Columbia University, 1949.

33. Reese, H. W. Discrimination learning set and perceptual set in young children, *Child Development*, 1965, *36*, 153–163.

34. Renshaw, S. *Psychology of vision* (Duncan, Okla.: Optometric Extension Program, 1942).

35. Rudel, Rita G., and Teuber, H. L. Discrimination of direction of line in children, *Journal of Comparative and Physiological Psychology*, 1963, *56*, 892–898.

36. Siegel, A. I. A motor hypothesis of perceptual development, *American Journal of Psychology*, 1953, *66*, 301–304.

37. Townsend, E. A. A study of copying ability in children, *Genetic Psychology Monographs*, 1951, *63*, 3–51.

38. Tresseit, M. E., and Simberg, A. L. A quantitative experimental investigation of the phenomenon of closure, *Journal of General Psychology*, 1953, *48*, 21–27.

39. Vernon, Magdalen D. *The psychology of perception.* Baltimore: Penguin Books, 1963.

40. Witkin, H. A. Individual differences in ease of perception of embedded figures, *Journal of Personality*, 1950, *19*, 1–15.