

## DEVELOPMENTAL CHANGE IN MOTOR ORGANIZATION: COVERT PRINCIPLES FOR THE ORGANIZATION OF STROKES IN CHILDREN'S DRAWING

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Copies of simple geometric figures were analyzed with 204 subjects from six age groups to assess developmental change in motor organization. Three types of organization of strokes and three principles for the use of the organizations were identified, and developmental change in the organization was found to be statistically significant. The distinction among the principles made it possible to determine that seemingly the same organization of different age groups resulted from different principles. The influence of potential handedness on the directionality of strokes was also found to be significant.

When preschool children draw figures or write letters, they organize their strokes in certain special ways. For example, when very young children are asked to copy a cross, some of them may draw it with four strokes, always starting each stroke from the central crossing point. Although, this organization might seem to be peculiar from an adult's point of view, children have their own principles for organizing strokes. Some scales of the development of children's abilities (e.g., McCarthy, 1972) contain a subtest in which simple figures are copied. However, these subtests often utilize only limited aspects of information available from the test. Sometimes they score only in such quantitative aspects of the products as straightness of lines, angles between lines, and so on, regardless of the types of organization of strokes used. To assess developmental change in the qualitative aspect of motor organization, it would be necessary to determine both an adequate classification of the types of organizations and developmental change in covert principles for the use of the types of organizations. For these purposes, in the present study, copies of simple geometric figures were analyzed with subjects of various age groups.

### METHOD

Subjects of six age groups (5-, 6-, 7-, 9-, and 11-year-old children and adults with a mean age of 21 years) were asked to copy simple figures. The two youngest groups

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were drawn from a kindergarten (mean age=5:0 and 6:0). The next three groups were first grade, third grade, and fifth grade children from an elementary school. The oldests were college students. Data from predominantly right-handed subjects were analyzed first, because the proportion of predominantly left-handed subjects in the present samples were very small (about 9 percent). The resultant number of subjects in each group were 40, 38, 32, 41, 29 and 24 respectively.

They copied eight simple figures (see Fig. 1) with the dominant (right) hand. All the figures were capable of being drawn with one continuous stroke. The models were printed individually on the upper half of a 25.6×18.1 cm paper. The subjects were instructed to draw the same figure as the model on the lower half of the paper with a felt pen. The order and the direction of strokes in drawing were recorded by trained observers.

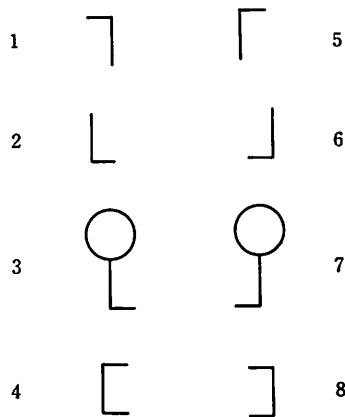


Fig. 1. The model figures

## RESULTS

Three types of organization of strokes were found to cover all the drawings (see Fig. 2): (A) *Fixed anchoring* — In this drawing type, each stroke always started from one end of a line. This type of organization was called fixed anchoring, for the same point (or line) served as an anchoring point for the start of strokes. (B) *Fluid anchoring* — In this case, lines were drawn successively from the end of the line drawn immediately before, that is, drawn with one continuous stroke. As with type (A), this type also required an anchoring point from which strokes start. However, the starting point which served as an anchor shifted in a successive way, and so this type is called fluid anchoring. (C) *Ballistic starting* — In this type of organization, strokes started from a point disconnected to the preceding line. This type differed from the former two in that it did not require anchoring.

Developmental change in the distribution of the types for each model is shown in Table 1. As shown in the rightmost columns of the table, statistically significant

associations were found between the type of organizations and age for all the models except for Model 2.

The youngest children (5-year-olds) were found to use both the fixed anchoring and the fluid anchoring. None of them used the ballistic starting. The next youngest group (6-year-olds) used the fluid anchoring almost exclusively. Other groups came to use all three types as their ages advanced (see Fig. 3). The student group used all the three.

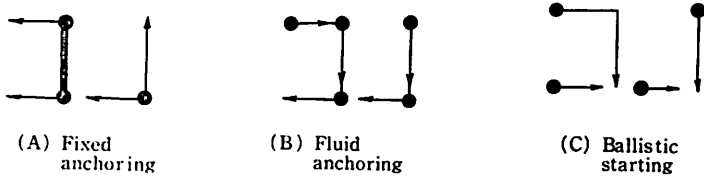


Fig. 2. Examples of the three types of organization

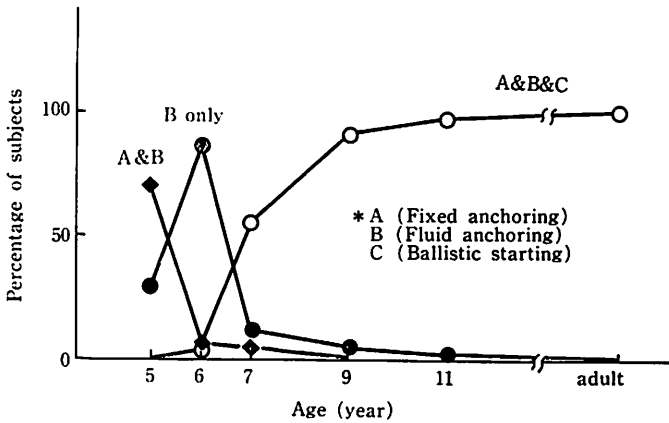


Fig. 3. Developmental change in the proportion of subjects who used each type of organization

Thus, this developmental change in the use of the three organizational types might suggest that fixed anchoring is developmentally the earliest, while fluid anchoring is the next, and ballistic starting the latest.

Further examination of developmental change in the use of the three types revealed an interesting fact. Elementary school children and students used the fixed anchoring as long as the drawings involved no right-to-left strokes (Model 4, 5), while the youngest children used fixed anchoring regardless of the directionality of movements. Students used all three types of organization, and their drawings were composed of only top-to-bottom and left-to-right movements. So it is concluded that the use of all the three types by students resulted from only one principle that all horizontal lines be drawn from left to right, and vertical lines from top to bottom. Thus three covert principles for the organization of movements can be identified: (1) The principle that all figures



be drawn with fixed anchoring. (2) The principle that all figures be drawn with fluid anchoring. (3) The directional principle, i.e. that vertical lines be drawn from top to bottom and horizontal lines from left to right.

A schematic description of developmental change in the principle for the organization of the strokes is shown in Fig. 4. The youngest group followed the first and the second principle. However the results of developmental change suggest that the first principle is developmentally the primary one. The next youngest group followed "fluid anchoring principle" almost exclusively. Following these two principles necessarily resulted in offending the directional principle in most figures. For example, if children copy Model 6 (the shape of reversed L) following the fixed anchoring or the fluid anchoring principles, they necessarily offend the directional principle (top-to-bottom and left-to-right). Elementary school children gradually shifted their principle to "the directional principle".

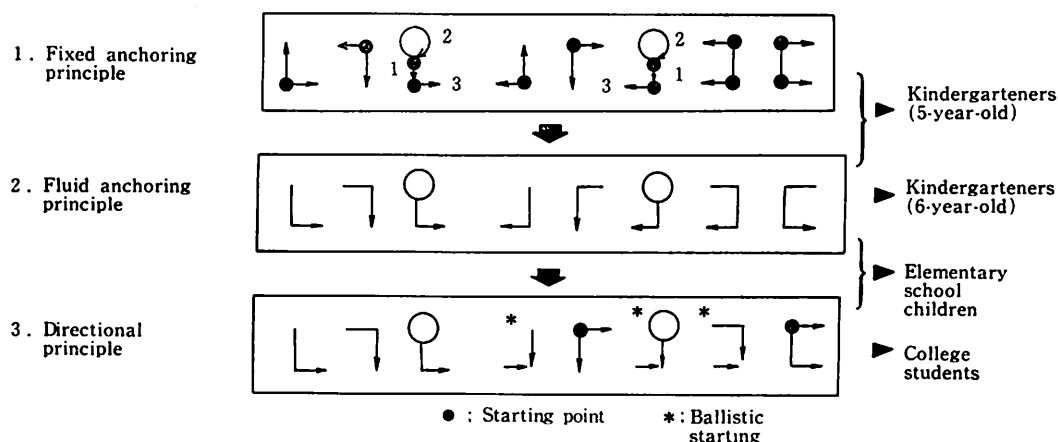


Fig. 4. Schematic description of developmental change in the principle for organization of strokes.

### DISCUSSION

The present study identified three types of organization of strokes, and found a developmental change in the covert principles for the use of the types. The distinction among the three principles enables us to recognize that seemingly the same organization of strokes by the youngest and by the adults resulted from different principles. For example, when drawing the shape of upside-down L ( $\Gamma$ ), both the youngest and the students drew it according to the same organization, that of "fixed anchoring". However, developmental change in the organizational principles suggests that the organization by the youngest children resulted from their following the principle that figures be drawn with a fixed anchor, and the students' drawing resulted from their following the directional principle that lines be drawn top-to-bottom and left-to-right.

Nino and Leiblich (1976) tried to characterize developmental change in the organization of strokes as increasing "degrees of freedom". However their elegant classification of drawings in terms of degrees of freedom failed to distinguish the developmentally earliest principle that figures be drawn with a fixed anchor from the next principle that figures be drawn with one continuous stroke, because both the two organizations are defined as having "zero degree of freedom" according to their definition.

As to the earliest principle, we might note that even the youngest children have well established directional "preference". When they draw a horizontal line or a vertical line in isolation with dominant (right) hand, they draw the line from left to right and from top to bottom, with rare exceptions (Nihei, 1976). Nevertheless, when they draw a figure, for example, the shape of reversed L (J), they follow the principle that figures be drawn with a fixed anchor at the cost of well established directional "preference". Developmentally the second principle was that figures be drawn with one continuous stroke. When this principle is followed, an anchor is not required to be fixed. The shift from the former principle to this might reflect, in part, the development of a sort of cognitively decentrating ability. The last organization to be developed is "ballistic starting". This type is necessary for the directional principle to be properly followed. Starting from a point disconnected to the preceding line would require the development of an ability to use imagery as a guide to drawing, as some authors have pointed out (Goodnow & Levine, 1973; Ninio & Leiblich, 1976). Thus there would appear to be a multiplicity of factors responsible for the development of the organization of movements.

Moreover, additional analyses revealed two interesting findings. First, so-called left-right reversal or mirror-reversal errors were associated with a directional preference (left-to-right) in right-handed children. Only children of the youngest two groups made copying errors; 30 percent of the youngest children (5-year-olds) and 8 percent of the next youngest children (6-year-olds). And 56 percent of the errors were left-right reversal errors. When the errors were examined, it was found that, in 88 percent of left-right reversal errors, children drew horizontal lines from left to right. This strong bias of drawing lines left-to-right in left-right reversal errors suggests the relatively great importance of the directional preference as one of the sources of the error. This implication corresponds well with the fact that the most frequently reversed letter is "S" in alphabets (Newson, 1955), and "< [ku]" in Japanese letters (Muraishi & Amano, 1972), both of which require starting in the non-preferred direction (right-to-left).

Secondly, adherence to the directional principle (left-to-right) of the student group was very much influenced by the subjects' potential handedness. There were five additional subjects, who were not perfectly right-handed, that is, who use the left hand only in such a very special situation as in washing rice or gripping a baseball bat. Drawings by four of the five subjects contained at least one drawing which did not

follow the directional principle, even though they ordinarily drawn and write with the right hand. Thus, the directionality of copies of figures used in the present study reflect the potential handedness, even of the weakest degree, especially in adults.

Finally, it should be noted that the explicit progress to the directional principle is possibly unique to Japanese children, because of the emphasis commonly placed by Japanese teachers on the directional principle in teaching writing.

#### REFERENCES

- Goodnow, J.J. & Levine, R.A. 1973 "The grammar of action": Sequence and syntax in children's copying. *Cognitive Psychology*, 4, 82-98.
- McCarthy, D. 1972 *Manual for the McCarthy Scales of Children's Abilities*. New York: The Psychological Corporation.
- Muraishi, S. & Amano, K. 1972 *Reading and writing ability in pre-school children*. The National Language Research Institute Report 45. Tokyo: Tokyo-Shoseki. (in Japanese)
- Newson, E. 1955 The development of line figure discrimination in preschool children. Ph. D. Thesis, Univ. of Nottingham. (Cited by Fellows, B.J. 1968 *The discrimination process and development*. London: Pergamon Press.)
- Ninio, A. & Leiblich, A. 1976 The grammar of action: "Phrase structure" in children's copying. *Child Development*, 47, 846-849.

#### REFERENCE NOTE

- Nihei, Y. 1976 Movement preference as a source of children's mirror-reversal errors in writing. *Paper presented at the 31th meeting of Tohoku Psychological Association*. (in Japanese)

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