The Grammar of Action: "Phrase Structure" in Children's Copying

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NINIO, ANAT, and LIEBLICH, AMIA. *The Grammar of Action: "Phrase Structure" in Children's Copying.* CHILD DEVELOPMENT, 1976, 47, 846–849. 30 4–5-year-old children copied a horizontal line, a vertical line, and an inverted T. Preference for a certain strategy in copying the compound figure was interpreted in terms of a simple phrase structure, one involving movements controlled with minimal degrees of freedom. Considerations of the total utterance in terms of semantics and phrase structure are necessary to account for copying patterns. In a second experiment, 163 children from kindergarten through sixth grade were given the inverted-T copying task. With increased age, children come to prefer increasingly complex combinational structures.

In a paper by Goodnow and Levine (1973), children's copying of simple rectilinear forms was analyzed in terms of rules that specify the choice of starting point and the direction of strokes. They claim that a small number of rules (e.g., Start at the top or the left of figure) adequately describe the strategies used for drawing various designs. Furthermore, the rules stabilized with increasing age. The authors suggested that these rules form "the grammar of action," according to which progression in the copying can be regarded as a sequence of choices made at points along the path.

From the point of view of the different grammatical systems, this suggestion could be most closely described as a Markov grammar, which is essentially a linear model. A model for copying geometric designs should, however, include considerations of the total design, the spatial relations it depicts, and the strategies for combinations of the movements necessary for the drawing. If copying is considered as a language system, these aspects could be regarded as its semantics, on the one hand, and its phrase structure, on the other.

Taking a T form, for example, its semantics would be: two line segments in specific directions, one common point bisecting one of the lines, and a 90° angle between the two lines. There exist 48 different ways to draw a T form correctly when both direction and order of movements are taken into account. These strategies fall into several categories, each with a different "syntactical structure." For example, the "semantical" relation of a 90° angle between the horizontal and vertical components of a T can be expressed by drawing two separate right angles on two sides of the junction; by starting with the horizontal and proceeding with the vertical line, using the junction as a point of departure; or by starting with the horizontal line and designating the junction as the end point of the vertical line. These alternatives differ as to their degree of difficulty and complexity, which is best defined in terms of the amount of cognitive load involved in choosing the starting point for the second-drawn line. In the third alternative, the choice of a starting point for the vertical line involves two degrees of freedom, while in the first two alternatives the corresponding choice has zero and one degree of freedom. Degrees of freedom in this context mean the number of dimensions of the starting point which have to be controlled by the stored requirements given by the model. Any overall drawing strategy of a T form that includes the third alternative has, as a consequence, the most complex "phrase structure." This study explores the relationship between surface directionality preferences and the phrase structure of drawing sequences.

The choice of a particular phrase structure might or might not determine the surface choice of starting points and directionality. Choice of the least and most complex structures for a T form does not restrict the free choice of starting points or directions of movement. On the other hand, choice of the intermediate structure (starting the second line from a point of departure on the first line) does restrict surface choices. In some cases, this general strategy might actually conflict with the rules suggested by Goodnow and Levine (1973), such as with an inverted (upside-down) T and a right-tilted (on its side) T. While Goodnow and Levine state that there is a general preference

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for the top–bottom and left–right directions, the choice of the intermediate combinational rule forces a bottom–top direction for the inverted T and right–left direction for the right-tilted T. Furthermore, according to Goodnow and Levine, there is an equal probability that the starting point will be either top or left, while the present hypothesis predicts, for the same underlying combination rule, a strong preference for the left for the inverted T and for the top for the right-tilted T.

Inspection of Goodnow and Levine's data indicates that departures from top–bottom, left–right directionality and left or top starting points occur mainly in the youngest age groups (4–5 years) copying figures including inverted and right-tilted T junctions. This pattern suggests that the youngest children in their study were using the intermediate (one degree of freedom) phrase structure defined above.

Although Goodnow and Levine do not report the starting point and directions of movement for the second lines in the drawings they used, it is sometimes possible to reconstruct the overall drawing strategies on the basis of the reported data. For the two youngest age groups, 4-5 and 5-2, in Goodnow and Levine's designs 10 (right-tilted T) and 13 (inverted L), the predominant starting stroke was the vertical one and the horizontal line was drawn mostly by a right–left stroke departing from the junction. Similarly, in design 11 (square-shaped capital U) the preferred strategy was to start with the horizontal line and the verticals were drawn from bottom to top.

The present study attempts to verify the predictions regarding the effects of the total design on the separate movements. The first experiment investigates the strategies of drawing single horizontal and vertical lines and an inverted T in 4–5-year-old Israeli children. The inverted T was chosen as the investigated design, because this figure had not been included in Goodnow and Levine's study and therefore its analysis makes possible the independent testing of the hypothesis.

Experiment I

Method

Subjects.—Thirty children attending a nursery school in Jerusalem served as subjects. The mean age was 4-4, and the age range was 3-11 to 4-10; there were 13 females and 17 males. The subjects mostly were from middle-class professional families, although some were from lower-middle-class families. All subjects were right handed.

Testing materials and procedure.—The subjects were tested individually. They were provided with white paper and crayons. Three model drawings on separate cards were presented to the subjects one at a time, and they were asked to "draw a form just like in the picture." The models were: an inverted T, each component line 3 cm long; a 10-cm-long horizontal line; and a 10-cm-long vertical line. The cards were placed on the table above the drawing paper.

The inverted T was presented first; then the horizontal and vertical models were presented in random order. The experimenter noted the position of the starting points for each component line and the direction of each separate movement.

Results

The direction of movements is presented in table 1. The tendency to draw the lines in the same direction in the single and compound figure was 86.7% for the horizontal lines and 56.7% for the vertical lines. The difference between them is significant, $z = 2.73 > 1.96$, $p < .05$.

It should be mentioned that six of the 12 subjects who drew both vertical lines in the top–bottom direction rotated the vertical component of the inverted T so that they drew an upright T. If these subjects are deleted from the data, the difference between the two tendencies is even greater: for the vertical lines, the tendency to draw both lines in the same direction was only

TABLE 1

DISTRIBUTION OF DIRECTIONS OF MOVEMENT IN COPYING THE HORIZONTAL AND VERTICAL LINES AND THE INVERTED T

	HORIZONTAL LINE OF T[a]		
SINGLE LINE	Right–Left	Left–Right	Total
Horizontal:			
Right–left	2	1	3
Left–right	3	24	27
Total	5	25	30
	VERTICAL LINE OF T		
	Top–Bottom	Bottom–Top	Total
Vertical:			
Top–bottom	12	13	25
Bottom–top	0	5	5
Total	12	18	30

[a] In those cases where the horizontal line was drawn in two separate strokes, the direction of the first stroke was considered for the table.

45.8%, compared with 86.7% for the horizontal lines.

With regard to the changes in direction between the compound and single figures, the tendency for the horizontal lines to change from the left–right to the right–left direction is similar to the tendency for the opposite change. In the case of the vertical lines, however, there is a significantly higher tendency to change from bottom–top in the compound figure to top–bottom in the single line. For horizontal lines, $\chi^2(1) = 1.0$, nonsignificant; for vertical lines, $\chi^2(1) = 13.00 > 10.83$, $p < .001$, using the McNemar test for the significance of changes (see Siegel 1956, p. 63).

Drawing Strategy of the Inverted T

Twenty-four subjects drew the inverted T with two distinct strokes, and six drew it with three strokes. For both groups, the dominant tendency was to start the second (and third) stroke at the junction of the vertical and horizontal lines. Only three subjects deviated from this "rule." Figure 1 illustrates the different strategies used.

The choice of the different strategies showed some developmental trends. For the three-stroke figures, the mean age of the subjects who used this strategy was 4-1; for all the two-stroke figures where the second stroke started at the junction, the mean age was 4-4; and for the two-stroke figures where the second stroke did not start at the junction, it was 4-8.

Discussion

Our study provides support for the claim that the progression of copying a design is mainly determined by the requirements of the total design, which seems to be analogous to the phrase structure of a verbal utterance. Although it was dem-

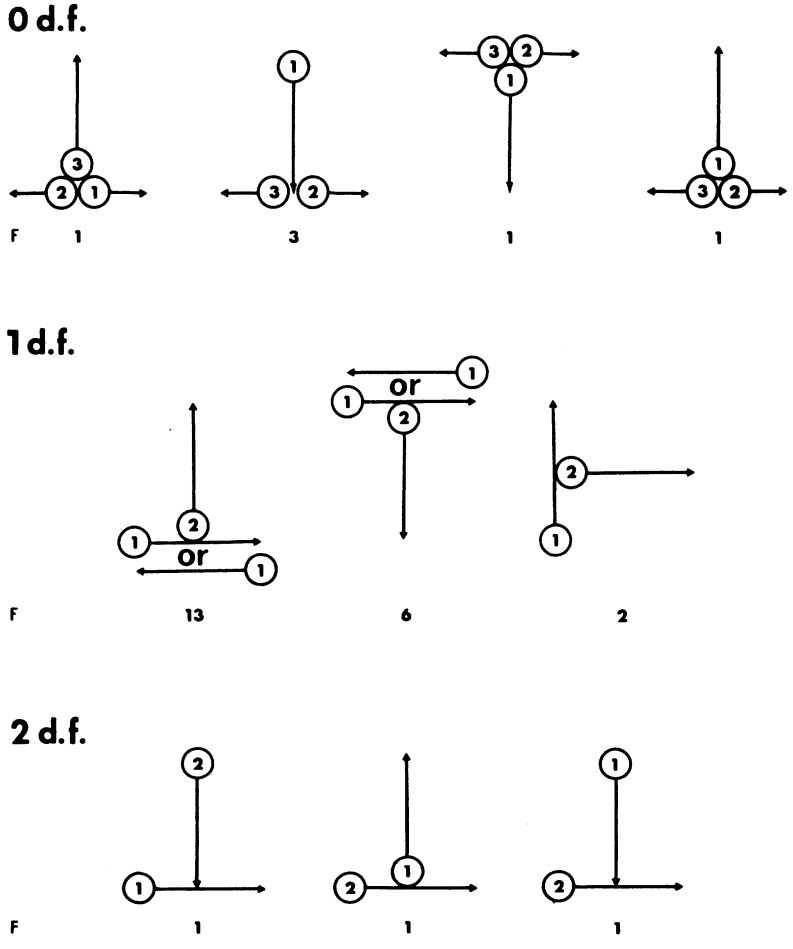

FIG. 1.—Strategies of drawing an inverted T, grouped by the number of degrees of freedom for the second starting point, with frequency of occurrence (*F*) in a nursery school sample.

onstrated that there are some rules of linear order, such as moving from top or from left, in young children there are some systematic departures from these rules. These departures seem to fit a hypothesis based on minimization of informational load, namely, that children prefer starting points for which one of the coordinates is already given and avoid those strategies which necessitate selection of starting points based on many "imaginary," stored characteristics of the model. A similar view was forwarded by Vereecken (1961), who claimed that the difficulty young children exhibit in copying a diamond form stems from the necessity to think in terms of "imaginary" lines.

The avoidance of complexity seems to be a characteristic of young children, but it is possible to offer the hypothesis that, with increased age, children come to prefer increasingly complex "phrase structures." This view is consistent with Bernstein's (1967) and Bruner's (1970) suggestion that, when a skill is initially brought under control, there is a tendency to minimize the degrees of freedom controlled at a given instant. Mastery of the skill is characterized by simultaneous control over increasing degrees of freedom.

Even within the restricted age range of the first experiment, some developmental trends can be observed. The modal strategy of the youngest group was to draw the inverted T with three separate movements, starting with the vertical and drawing the two horizontal sections as departures from the common junction. The medium age group selected a modal strategy of starting with the horizontal line and drawing the vertical from the junction up. Only in the oldest age group did some children evince the "adult" pattern, namely, not starting the second line from the junction. These three strategies form a scale of amount of stored information required for the selection of the starting point (zero, one, and two stored dimensions).

In order to fully test the developmental hypothesis, additional age groups were tested with the copying task.

Experiment II

Method

Subjects.—Seven groups of children served as subjects, 20 in kindergarten and 25, 20, 25, 26, 26, and 21 in first through sixth grade, respectively. The socioeconomic status of their families was similar to that of the nursery school sample of Experiment I. All subjects were right handed.

Testing materials and procedure.—These were the same as in Experiment I.

Results

Only the results on drawing strategy are reported here. (For a report on drawing directionality of single lines, see Lieblich, Ninio, & Kugelmass [1975].)

Figure 2 presents the percentage of subjects using each of three strategies (zero, one, or two stored dimensions) in the seven age groups sampled in this experiment and in the nursery school sample of Experiment I.

Discussion

The results of this experiment demonstrate the existence of the hypothesized developmental trend in preference for more complex combinational rules or "phrase structures" of drawing.

Inspection of Goodnow and Levine's (1973) results indicates additional combinational rules in young children which might be regarded as further demonstration of the importance of "phrase structure" in drawing. These rules are:

1. When two lines are of unequal length, start with the longer one.

2. When a design is composed of two separate nonintersecting lines, start the second one from the point nearest the first one.

3. Return to the starting point rather than "thread" (i.e., draw with a continuous line).

4. In compound designs that include both junctions and parallel lines, draw all relative directions as angles between intersecting lines.

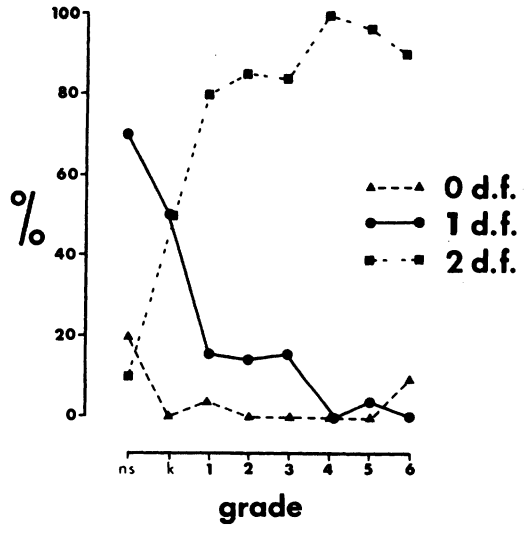

FIG. 2.—Distribution of strategies for drawing an inverted T, by the number of degrees of freedom for the second starting point and by grade of subjects.

Some of these rules seem to change with age. More data are necessary to describe these rules and their developmental trends in detail.

These rules deal with the combinational activity underlying overt sequential movements in drawing, rather like the phrase structure that is supposed to underlie the surface structure of a grammatical sentence. The analogy between the dual structures of motor activity and grammar is similar to that drawn by Goodson and Greenfield (1975) between grammar and construction activity. They identify three structural principles, two of base structure (hierarchical complexity and role change) and one of surface structure (interruption), and suggest that they operate both in language and in action, determining relative cognitive complexity within each domain. There is a possibility that the combinatorial tendencies found in the reported study reflect yet another general cognitive principle.

One final word should be added regarding the possible influence of Hebrew on the drawing directions of the studied group. As Hebrew is written from right to left, it could be expected that the dominant movement in drawing would shift more in this direction. Several studies investigated this hypothesis in various age groups (Goodnow, Friedman, Bernbaum, & Lehman 1973; Lieblich et al. 1975), and some concentrated on directionality in perceptual exploration (Kugelmass & Lieblich 1970; Kugelmass, Lieblich, & Ehrlich 1972). While a tendency of right–left preference in perception was indicated for the Israeli samples, this was not clearly the case for the drawing movements.

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