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Development of Structure and Strategy in Two-Dimensional Pictures

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The development of two structural principles, hierarchical complexity and interruption, was examined in a new domain, two-dimensional pictures. Using felt pieces, 4- to 5½-year-olds were asked to reproduce felt pictures of flower arrangements constituting tree structures of different levels of hierarchical complexity. For each model, task difficulty was varied by requiring children to construct pictures either with whole flowers or with component pieces. The ability to reproduce the models formed a Guttman scale according to tree structure complexity, and older children scored higher on the scale than younger children. Thus, hierarchical complexity has a developmental role in the pictorial domain, as in language and three-dimensional construction. The construction process was analyzed in terms of uninterrupted and interrupted strategies. Unlike earlier results with abstract (nonfigural) three-dimensional construction tasks, children did not avoid interrupted strategies. The lack of strategy preference with whole flowers and the development of a preference for interrupted strategies with components may stem from the fact that the strong figural and thematic aspects of the models reduced the cognitive complexity of an interrupted strategy.

Recent research has documented common structural principles that affect the development of action strategies and language. One of these principles, hierarchical organization, involves the ability to combine *low-level* elements into *higher order* elements. Hierarchical organization in construction has been studied with a variety of materials; such as seriated cups, wooden models, a plastic straw mobile, and wooden block arches (Forman, Kuschner, & Dempsey, 1975; Goodson & Greenfield, 1975; Greenfield, 1978; Greenfield, Nelson, & Saltzman, 1972; Greenfield & Schneider, 1977; Greenfield & Hubner, Note 1). In all these media, simple pairing or chaining strategies that involve forming a lower level unit and using that unit as part of a higher order unit preceded subassembly strategies. The ability to create structures requiring more hierarchical levels developed with age in each representational medium.

Children also exhibit an increasing ability to deal with hierarchical complexity in another domain, language. Language involves several combinatorial levels—phonological, morphological, and syntactical. Once words are combined, further hierarchical complexity is apparent with the acquisition sequence of simple sentences, compound sentences, and then sentences with clauses (Brown, 1973; Ingram, 1975; Limber, 1973). Hierarchical complexity can also predict children's development in the conceptualization of recursive thought (Miller, Kessel, & Flavell, 1970).

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The ability to reproduce a structure from any point relates to a second structural principle, interruption, manifested in the development of action strategies and language. In an interrupted action strategy, children must keep track of the incomplete unit so that they can go back to it after finishing the current unit. Similarly, in center-embedded sentences, part of the main clause must be retained while the embedded clause is processed or produced (Bever, 1970; Slobin, 1971). In action strategies and language, younger children produce uninterrrupted forms to a greater degree than older children (Goodson & Greenfield, 1975; Greenfield & Schneider, 1977; Menyuk, 1969; Slobin & Welsh, 1973). Younger children show a preference for uninterrupted forms even when they can produce interrupted forms (Goodson & Greenfield, 1975; Greenfield & Schneider, 1977; Sheldon, 1972, 1973).

The purpose of the present study was to investigate systematically the developmental role of hierarchical organization and interruption in a new domain, two-dimensional pictures. Previous research suggests that hierarchical organization should predict performance in this domain, just as in action strategies and language. Children's spontaneous and prompted drawings demonstrate increasing hierarchical complexity (Kellogg, 1969; Piaget & Inhelder, 1967; Vereecken, 1961; Alaniz, Note 2).

Researchers have also investigated children's perception of part–whole relationships. Anisfeld (1968) had kindergarten children sort pairs of picture cards on a singular–plural dimension. Significantly more correct responses were made when plurality was represented by a multiple number of objects than when it was represented by a greater number of features embedded in the object, a result implying that the embedding relationship creates cognitive complexity. Elkind, Koegler, and Go (1964) asked 4- to 9-year-old children to describe complex stimuli such as a face composed of a lampshade, two lightbulbs, and a telephone receiver. They found a regular increase with age in the ability to describe the whole as well as the parts. Both studies showed that young children do not integrate the part–whole relation; that is, they seem unable to use hierarchical structuring in sorting and description tasks, whereas older children do.

Also, recent research suggests that the interruption of units might be relevant in the construction of two-dimensional pictures. The sequence or temporal order of lines used by children in copying graphic designs was initially conceptualized by Goodnow and Levine (1973) in terms of *syntactic aspects*. Ninio and Leiblich (1976) further clarified the existence of alternate orderings, and they found a developmental change toward using more complex construction sequences. Younger children preferred starting points with specified coordinates (fewer degrees of freedom), which minimizes the information load during drawing. For example, when drawing an *inverted T*, younger children tend to draw the vertical line up from the horizontal line, whereas older children tend to draw the vertical line down to meet the horizontal line. The first strategy involves manipulating one dimension (one degree of freedom), the vertical dimension, since the horizontal line serves as the point of departure for the vertical line. In contrast, the second strategy requires manipulation of two dimensions (two degrees of freedom), since the vertical line starts out in space at a new locus. Degrees of freedom in drawing resemble interruption in construction and language; studies in each domain show that younger children will select cognitively simpler strategies.

In the present study we operationalized hierarchical complexity in terms of branching tree structures. The models, configurations of flowers and pots, allowed the inclusion of several levels of hierarchical organization (see Figure 1). In one model, all the flowers originate from the pot; that is, they are all at the same level (one-level model). In the two-level model, each flower has a branch, thus the main stems represent one level and the branches a second level. This model could also be conceptualized as the shorter branch being embedded in the longer branch. In the most complex model, the branch has subbranches, hence there are three levels—the main stem, the branch, and the subbranches. Note that structure varies across these models, whereas the components (number and type) are held constant.

The other two models were considered one-level models, since they were nonbranching (see Figure 2). One consisted of five flowers in a row, and the other was a five-flower chain. Based on the notion that structure is a critical variable, our hypothesis was that the ability to reproduce the models would form a Guttman scale. The one-level models should be easier to reproduce than the two-level model, which in turn, should be easier than the three-level model. We were unable to predict differences between the one-level models based on hierarchical complexity. Because the ability to represent a given level of hierarchical organization was hypothesized to be a developmental phenomenon, it was

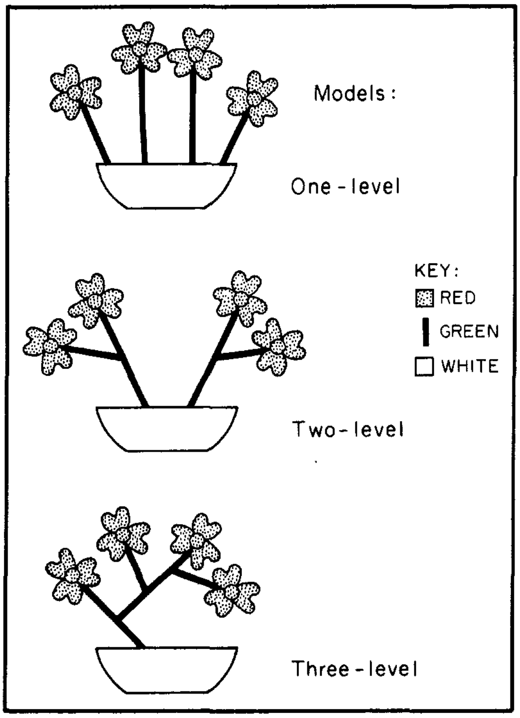

Figure 1. Flower pot models at three levels of hierarchical complexity.

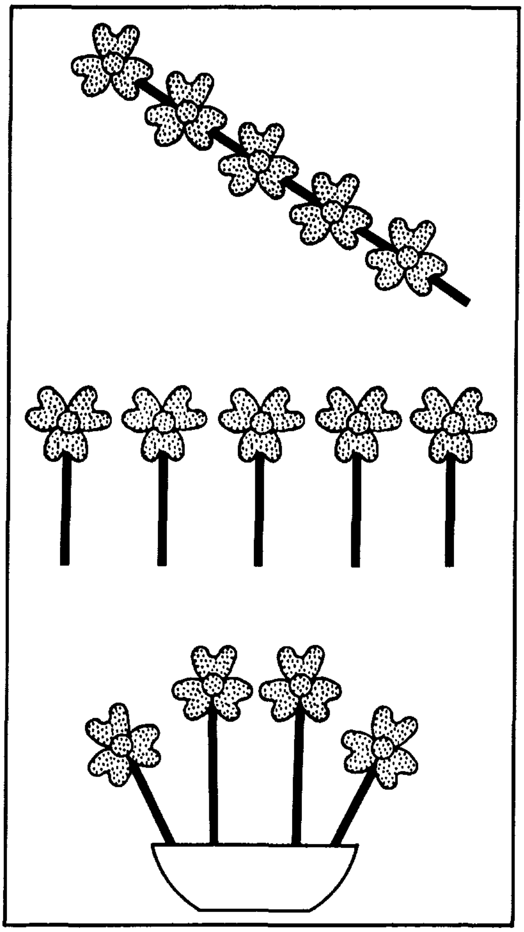

Figure 2. Models at the lowest level of hierarchical complexity.

also predicted that older children would be able to construct more complex and therefore more models than younger children.

In addition, task difficulty was varied between a condition in which children built configurations out of complete flowers and a condition in which children built configurations out of components (petals, centers, and stems). Inclusion of both conditions afforded the opportunity to vary the hierarchical complexity of each model, thereby increasing the total cognitive complexity. For example, constructing the three-level model with whole flowers involves three levels—the main stems, branching stems, and subbranches (Figure

1). Constructing the two-level model with components also involves three levels—main stems, branching stems, and blossom pieces. Thus, children who had mastered but three hierarchical levels would be able to construct the three-level model in the whole-flower condition but would be limited to the two-level model in the components condition.

Even though felt forms were selected as the representational medium to minimize manipulative factors, different construction strategies were possible. (A strategy is here conceived as a principle for determining the order in which elements will be added.) Our last prediction was that the spontaneous use of interrupted strategies would increase with age. In order to talk about interruption, it is first necessary to identify the units that can be interrupted. Whereas it was a matter of structural units in the earlier three-dimensional construction tasks, the two-dimensional stimuli in this study were composed of figural units. We conceived of the flower plant as the figural subunit that might or might not be interrupted in the construction process. Figure 3 presents examples of interrupted and uninterrupted strategies for building the one-level models out of component pieces.

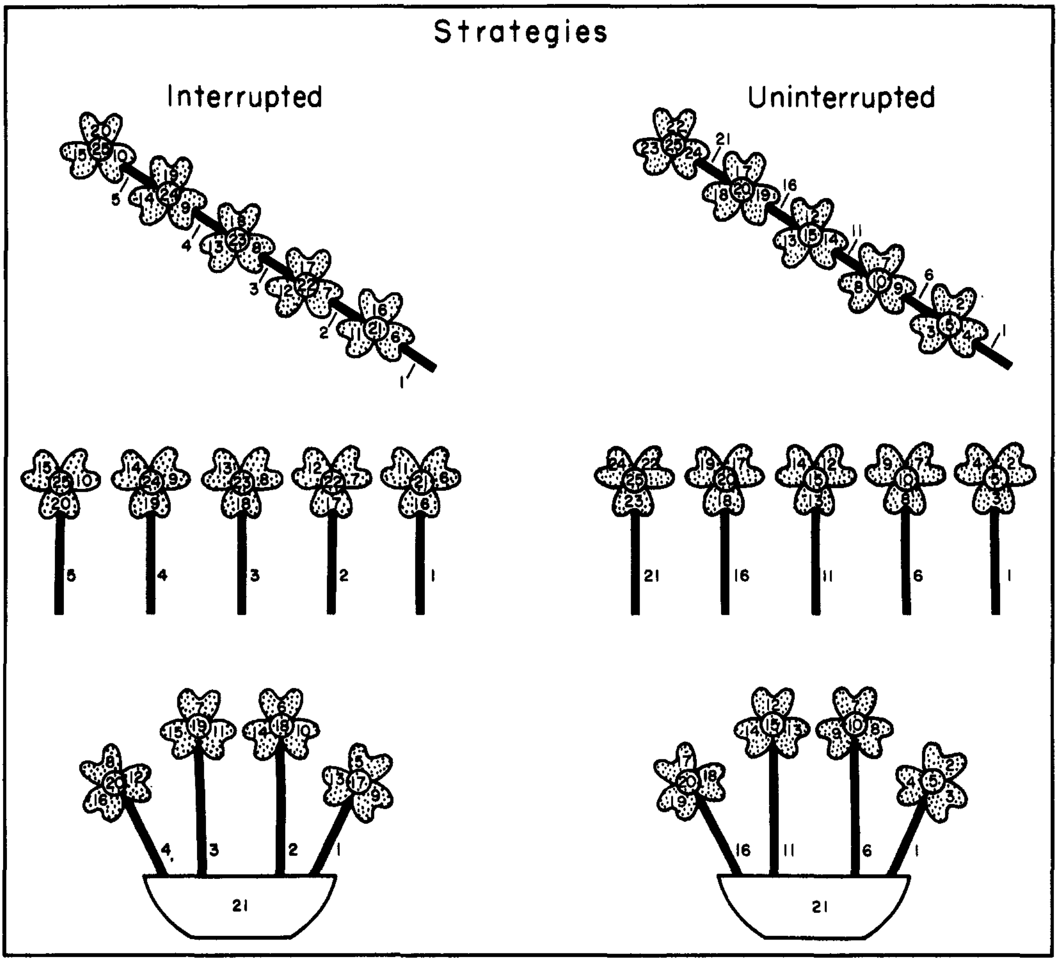

Figure 3. Alternative strategies for the one-level models built from component pieces. (Numbers designate the order in which pieces were added.)

Method

Subjects

The participants were 60 children who attended a church-affiliated preschool in a middle-class neighborhood. There were 20 children in each of the following age groups: 4–4½, 4½–5, and 5–5½ years. There were 28 girls and 32 boys.

Design

Half of the children in each age group were randomly assigned to work with components, and the other half worked with whole flowers. Each child saw the same five models. The sequencing of models was evenly divided between the following two orders: five *flowers in a row, chain, four flowers in a pot,* two-level model, and three-level model, or the reverse. The starting point in each of these orderings was randomly determined for each subject. The presentation sequences were matched between the two levels of task difficulty.

Subsequently, competence with alternative strategies was investigated for every one-level model correctly copied by a child in the component-pieces condition. The one-level models were selected because pilot work indicated that the majority of the children would succeed with the one-level models, and the children balked at redoing *all* five models. An attempt was made to elicit another strategy by modeling. The two types of strategies modeled were extreme versions of an uninterrupted and an interrupted strategy (see Figure 3). Children who had initially used an uninterrupted strategy were shown an interrupted one, and vice versa. In the whole-flower condition, only the two-level model allowed a choice of strategies varying according to whether the flower plant was interrupted. All children who correctly copied this model were shown an alternative strategy, again uninterrupted or interrupted depending on initial strategy (see Figure 4). Because children in pilot testing always placed the flower pot first, it was decided always to place it last when modeling alternative strategies (see Figures 3 and 4).

Procedure

Each child individually agreed to leave the classroom with the experimenter to make pictures of flowers. Once in the experimental room, the child saw himself or herself on the small monitor of the portable videotape equipment. After the child was comfortable in the experimental situation, he or she was seated in front of an 8½ × 11 in (21.6 × 27.9 cm) black board and appropriate felt pieces. Children in the components condition were given red petals, red centers, short green stems, long green stems, and white flower pots, whereas children in the whole-flower condition were given white flower pots and complete flowers. The complete flowers were formed by gluing short or long green stems to the back of red blossoms. The different piles of felt pieces were described, and the child was asked to point to the short stems or short flowers and long stems or long flowers, respectively. Then, the child was told that a picture would be shown and that the felt pieces should be used to make the same picture on his/her board. The child was also told that his/her picture would be taken while making the picture. Finally, the child was told that there was no hurry and to tell the experimenter when the picture was done.

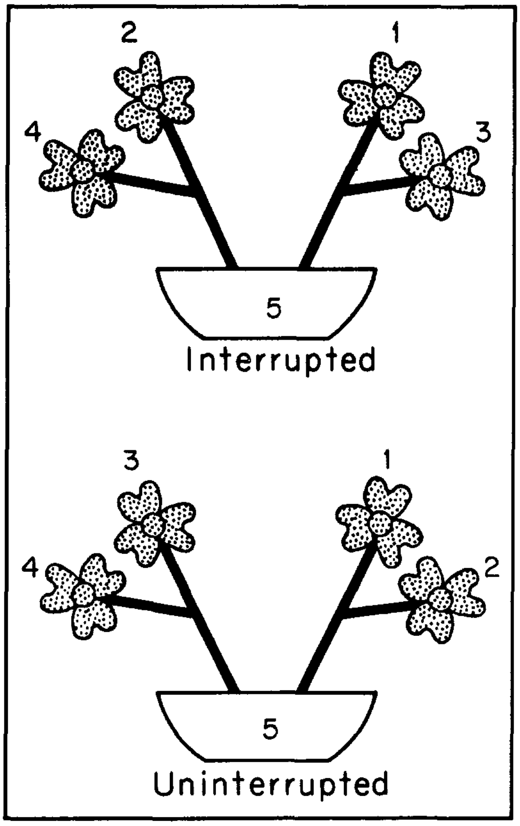

Figure 4. Alternative strategies for the two-level model built from whole flowers. (Numbers designate the order in which pieces were added.)

After the child understood the instructions, a model was displayed with a reminder to *try* to make the same picture. The construction process was videotaped from the time the child first touched the felt pieces until the child indicated he/she was done. Any spontaneous comments about the models or the task were recorded by the experimenter. The model was always present during the construction process to minimize the memory factor. When the child signified that he/she was finished, the child was given a choice between making another picture or returning to the classroom. If the child chose to make another picture, a new board and another model were placed in front of the child. When the child wanted

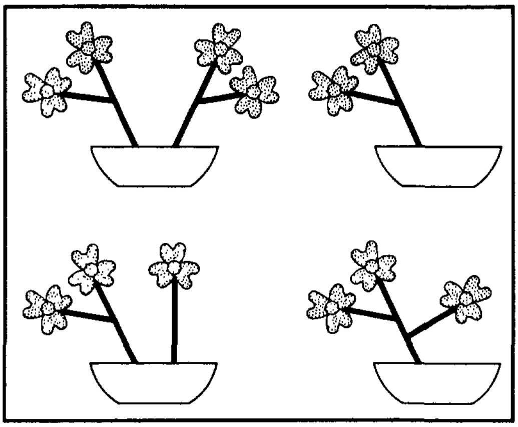

Figure 5. Examples of structurally correct and incorrect reproductions for the two-level model. (The upper-left configuration is an identical copy. The upper-right configuration only has two flowers and would not be scored correct. The two lower configurations have three flowers as well as subbranching flowers, hence they would be scored correct.)

to return to the class or all five pictures were completed, each model and the child's corresponding reproduction were shown to him or her in turn. The child was asked if the two pictures were the same for each pair.[1] After the child returned to the classroom, a still black-and-white photograph was taken of each construction. If a child did not finish in one session, the same procedure was repeated until all five models had been displayed.

Children whose copies were *structurally correct* for the one-level models in the components condition and for the two-level model in the whole-flower condition participated in a second task. The appropriate one-level models were shown in their original sequence for children in the components condition; the two-level model was used for children in the whole-flower condition. The above procedure was followed again except for the task instructions noted. The child was told that the experimenter was going to make a picture and that the child should watch because he/she would have to do their picture the same way. The experimenter then showed the child a model, took it apart, and then reconstructed the model with the appropriate pieces using an alternative strategy to the one spontaneously used by the child for that model (see Figures 3 and 4). The child was then given a board and asked to make the picture the same way, that is, to put on the pieces in the same order.

[1] These judgments were not analyzed because they did not seem valid. Several children told the experimenter that a discrepant construction was the same and later told a teacher or parent that they could not make the picture.

Coding

The still photograph of each construction was used to decide if a model had been correctly reproduced. The criterion for a correct reproduction was the completion of the structural relation between *all* parts, that is, the correct number of levels. The pot was considered intrinsic and was required for the models pictured in Figure 1. Also, at least three flowers, the minimum number needed to represent the most complex structural relation, needed to be constructed. In the component-pieces condition, a child had to use a stem, a center, and a petal to be counted as having constructed a flower. These criteria are less stringent than the requirements for an identical copy. For example, with the two-level model the child needed to create at least one branching flower and an additional flower to be counted correct. Figure 5 shows examples of correct and incorrect reproductions for the two-level model. Requiring three flowers for all models eliminates a scoring bias across levels of hierarchical complexity, since two flowers can represent the basic structural relation in the one- and two-level models whereas three flowers are needed in the three-level model. Thus, this scoring criterion insures that the same number of components are required at all levels of hierarchical complexity. (See Discussion for further comments on scoring criterion.)

The order of adding on pieces was determined from the videotapes. One of two observers diagrammed the construction and numbered the pieces on a scoring sheet. The two observers worked together during pilot testing until agreement was perfect. Preference was based on a child's initial performance, and competence was judged by comparing the child's second construction process to his or her initial spontaneous construction process. If the second construction process was appropriately more interrupted or more noninterrupted than the initial construction process, the child was considered competent with both strategies.

Results

Ability to Reproduce the Models

A preliminary analysis of the number of correct items for each subject showed that there were no sex differences in either condition, $t(28) = .83$ and $t(28) = .00$, $p > .05$. Consequently, the variable of sex was not included in further analyses. Nearly half of the children (45%) showed *error patterns*, that is, they neither correctly completed all five models nor failed all five models.

Over both conditions, the five models formed a Guttman scale with a reproducibility of .96 and an index of consistency of .73. An index of consistency greater than .5

Table 1
Percentage of Children Correctly Reproducing the Basic Structure of Different Models

Model				
One level				
Row	Four flowers in pot	Chain	Two level	Three level
80	80	75	68	50

Note. All percentages are based on a sample size of 60.

designates scalability (Green, 1956). As predicted, the results of the scaling showed that the one-level models were easier to reproduce than the two-level model, and the two-level model was easier than the three-level model. Thus, children who could reproduce a certain level model could, in general, also reproduce any lower level model.

The one-level variations seemed equivalent in difficulty since approximately the same percentage of children succeeded on each of them (see Table 1). Pairwise comparisons were made between the models using the multiple-sign test. ($S+$ refers to the number of children who could build the lower level model but not the higher level model. n refers to the number of children who could only build one of the two models referred to in the text.) Each one-level model was significantly different from the three-level model ($n = 19$ and $S+ = 18$ for four flowers in pot, $n = 22$ and $S+ = 20$ for row of flowers, and $n = 21$ and $S+ = 18$ for chain of flowers, $p < .05$). None of the one-level variations was significantly different from each other or the two-level model, and the two-level model was not significantly different from the three-level model ($n = 15$ and $S+ = 13$, $p > .05$). Nevertheless, the percentage of children succeeding on the two-level model is intermediate between the percentage succeeding on the one- and three-level models. The percentages succeeding on the three one-level models are closer to each other than to the percentage succeeding on the two-level model.

Each subject was given a scale score based on the number of models correctly

Table 2
Mean Scale Score for Each Age Group and Condition

Condition	Age group (in yr.)		
	4–4½	4½–5	5–5½
Component pieces	1.5	2.9	4.0
Whole flowers	3.4	4.6	4.8

reproduced. The possible scale scores ranged from 0 (no models correctly reproduced) to 5 (all models correctly reproduced; see Table 2). An analysis of variance was performed on these scores. The main effects of age and condition were significant, $F(2, 54) = 10.27$ and $F(1, 54) = 16.81$, respectively, $p \leq .05$, whereas the interaction was not significant, $F(2, 54) = .89$, $p > .05$. Post hoc comparisons showed that the youngest children had significantly lower scores than the oldest children, Tukey (b), critical difference of 1.51 for $p \leq .05$. Thus, the older children scored higher on the scale than younger children, and the models were more difficult to construct with components than with whole flowers.

To compare the ability to deal with hierarchical complexity between the whole-flower and component-pieces conditions, we used only scores from the three models pictured in Figure 1 so that each level was only represented once. Thus, a difference of 1 represents a difference of one hierarchical level. The average number of correct models for each age group and condition are shown in Table 3. Since the oldest group shows a ceiling effect when using whole flowers (mean score of 2.8 with 3.0 being

Table 3
Mean Number of Correct Reproductions of the Models Shown in Figure 1 for Each Age Group and Condition

Condition	Age group (in yr.)		
	4–4½	4½–5	5–5½
Component pieces	.8	1.5	2.4
Whole flowers	1.7	2.7	2.8

maximum), the comparison between conditions is restricted to the two younger groups. For these younger groups, the scores are about 1 less for the component-pieces condition relative to the whole-flower condition. We used a t test to test for an exact difference of 1, and it is plausible to infer an exact difference of 1 between the two conditions, $t(38) = .15, p > .05$. Hence, assembling the flower unit did add about one additional level of hierarchical complexity to the construction of a given model.

Strategies for Reproducing Models

The spontaneous process of construction was investigated for identical copies to see what strategies were associated with success at different developmental levels. In the components condition, construction strategies could be classified as uninterrupted and interrupted for all five models. If flowers were completely built (stem, center, and petals) before starting another flower, the strategy was considered uninterrupted. If flowers were not completely built before starting another flower, the strategy was considered interrupted (see Figure 3 for examples). For the two-level model, if a flower and branch unit was not completed before another flower was started, the strategy was also considered interrupted.

The spontaneous construction processes that led to identical copies in the components condition were classified for all five models. Only one child created identical copies in the youngest group, so developmental comparisons were limited to the two oldest groups. In the intermediate group, four children used uninterrupted strategies and one child used an interrupted strategy. All of the successful five flowers in a row copies were created with an uninterrupted strategy. Of the oldest children, six showed a preference for the interrupted strategy and one showed no preference for either strategy. The developmental change toward interrupted strategies is statistically significant at the .05 level, according to Fisher's test.

Children who copied identically at least one of the nonbranching models with components were shown alternative strategies in another session. Nine of the original 11 children were available to be shown alternative strategies. With the exception of one child, all of the subsequent constructions were appropriately more interrupted or more uninterrupted than the initial construction. Thus, younger children showed the same underlying competence with interrupted strategies as older children, even though their spontaneous performance of such strategies was significantly less. Interestingly, children who saw interrupted strategies (see Figure 3) did not separate the stem, petals, and centers, but separated the stems from the petals and centers. Even though the pot was added last in the demonstrations, four of the nine children did not add it last.

Spontaneous construction processes were also analyzed for the children working with whole flowers on the two-level model. If a flower and branching flower plant was completed before the other plant was started, the strategy was considered uninterrupted. If a two-flower plant was not finished before the other one was started, the strategy was considered interrupted (see Figure 4). Strategies were analyzed for the 20 children producing identical copies. The youngest group produced three uninterrupted strategies and two interrupted strategies, and the intermediate group produced four uninterrupted strategies and three interrupted strategies. The oldest group produced five uninterrupted strategies and three interrupted strategies. Over the 20 children, there was no significant preference for either strategy (binomial, $p > .05$), and there was no significant developmental change between any age groups (Fisher's test, $p > .05$). These results contrast with the relation between age and strategy shown by children working with the component pieces.

All 20 children who copied identically the two-level model in the whole-flower condition were shown an alternative strategy (see Figure 4). Four of the 5 4-year-olds were able to vary their construction process, and 3 of the 7 4½-year-olds were able to vary their construction process. Six of the 8 5-year-olds showed competence with the alternative strategy. Thus, 13 of these 20 children were able to use both strategies. Finally, about half of the children in each age group placed the flower pot on last as demonstrated.

Discussion

First, we predicted that the one-level models would be easier to reproduce than the two-level model, which, in turn, would be easier than the three-level model. The predicted ordering of hierarchical organization was upheld across two levels of task difficulty. The differential difficulty of the models is striking because all models were visible throughout the construction process; clearly, picture reproduction is heavily dependent on the cognitive processing of structure. A potential alternative explanation of these results might be that children must perceive and construct *more* parts to achieve greater hierarchical complexity and that it is this strictly quantitative requirement, rather than the qualitative feature of hierarchical structure, that generated the ordering from least to most difficult.

On the perceptual side, the models were equated for number of objects pictured (a total of five). In addition, one model at each level was also equated for type of parts and complexity of nodes or junctions in each condition (see Figure 1). On the construction side, the quantitative factor cannot account for the fact that the three-level model was more difficult to construct than the two-level model or that the two-level model was more difficult to construct than the one-level model, since the minimal number of flowers required to receive credit for the basic structural relations for each of these models was identical—three flowers. Because of this, any child who received credit for the one-level model would have manifested the ability to make a picture using three flowers, the minimum necessary for the basic structure of the three-level model. Also, requiring the pot did not affect the ordering of the models. First, not a single reproduction of a model containing a pot was scored incorrect just because the pot was missing; reproductions lacking the pot also failed to meet other criteria. Hence, the presence or absence of the pot alone did not affect the results. Second, the four flowers in a pot model was equivalent in difficulty to the row of flowers model and easier than the chain of flowers (see Table 1). This shows that the pot did not affect difficulty.

Therefore, the alternative hypothesis that children who fail in constructing higher order hierarchical models do so simply because they are unable to perceive and combine the required number of elements in one picture receives no support. Our original hypothesized explanation—complexity of hierarchical structure—remains the only possible explanation for the scaling results.[2]

Second, we predicted that forming the flower subunit from component pieces would add an additional level of complexity to each model. This was confirmed by comparing performance under the two conditions for the one-level, two-level, and three-level models pictured in Figure 1 (see Table 3). For the two younger groups, scores were about 1 less in the component-pieces condition relative to the whole-flower condition. Thus, the hierarchical complexity of the construction task itself contributes to cognitive complexity independent of the perceptual characteristics of either the physical display or the required copy.

The results also showed a mastery of increasing hierarchical complexity with development. Children who reproduced a certain level model could also reproduce all lower level models; that is, constructing the three-level model entailed the ability to construct the two-level model and the one-level models. On the average, the youngest children could only reproduce the one-level models, and the older children

[2] The initial spontaneous comments made by 21 children were consistent with the scaled ordering. The three-level model elicited comments such as "That's too hard," and "I can't do that," whereas the row of flowers model elicited comments such as "That's easy." None of the children stated that the three-level model was simple, and none of the children indicated that the row of flowers or four flowers in a pot was difficult. Scale scores and children's comments indicate that the complexity of hierarchical organization in the two-dimensional models had psychological significance for the children.

could reproduce the two-level and three-level models (see Table 2). Thus, hierarchical complexity predicts the development of children's performance with two-dimensional pictures, just as earlier studies have demonstrated for language development and three-dimensional construction (Goodson, 1977; Goodson & Greenfield, 1975; Greenfield & Schneider, 1977; Greenfield & Hubner, Note 1).

Our third area of interest was the sequence of elements, that is, the construction process itself. In prior research on three-dimensional construction tasks, children have tended to avoid interrupted strategies (Goodson & Greenfield, 1975; Greenfield & Schneider, 1977; Greenfield & Hubner, Note 1). That was not the case here; across age and condition, 48.5% of the children spontaneously used an interrupted strategy. This difference may stem from the fact that with these tasks, the figural aspects of the models were strong enough to help the child keep track of his or her place, thus removing the cognitive difficulty of an interrupted strategy in this situation.

Competence with interrupted strategies developed with age when children were observed building a complex mobile (Greenfield & Schneider, 1977). When the task was simpler (involving fewer pieces), as in the Goodson and Greenfield (1975) study, competence with an interrupted strategy was present as soon as the basic structure could be built. Our pattern of results for competence resembles that of Goodson and Greenfield: At every age most children who could copy a model could do so using either an interrupted or uninterrupted strategy. Again, the figural or thematic qualities of the models may have reduced the cognitive complexity of the interrupted strategy.

Although our strategy results in the component-pieces condition agree with the mobile-construction study in showing a development toward more interrupted strategies in spontaneous construction, they differ in that the older children show an overwhelming preference for the interrupted strategy in reproducing two-dimensional pictures. In the mobile study, only about half of the oldest children preferred an interrupted strategy. It may be that the figural or thematic qualities of the model not only reduced the difficulty of an interrupted strategy but even made it more efficient. In the components condition an interrupted strategy means that the framework (stems) can be laid out at once and the rest of the picture filled in later. For the essence of the structure, the child would only need to retain the relation between five elements (four stems and a pot or five stems). Once the stems are positioned, adding the flowers becomes a redundant process. Using an uninterrupted strategy, in contrast, the child has to keep the structure in mind while constructing each blossom. This predictability of one part from the other (blossoms from stems) was absent from the earlier abstract construction tasks in which preferences for interruption did not develop (Goodson & Greenfield, 1975; Greenfield & Schneider, 1977; Greenfield & Hubner, Note 1).

This explanation relates to a second point, the type of interruption or levels of units utilized by the children working with component pieces. Children who spontaneously interrupted predominantly separated the stem from the blossom composed of petals and a center. Even when a layer-by-layer strategy was demonstrated (see Figure 3), the children tended to avoid interrupting the blossom, merely forming a layer of stems and a layer of blossoms. This division yields what seems, in theory, to be the cognitively most efficient strategy: Stems are laid down first to form the structural framework; then the flowers can easily be placed in their obvious position. It is obvious in the sense that it can be deduced from knowledge of flowers, without reference to the model. Out of several possible divisions, this particular one was selected by the children. In accordance with a hierarchical network theory of perception (Palmer, 1977), objects are multilevel, and not all possible elements are considered parts. Some elements form *good* or whole units. The blossom may have been a good unit because of the uniformity of color, the primary topological relation of enclosure, or its significance as an object.

Another interesting aspect of strategy was the prevalence of *pot-first* strategies in both conditions at all ages. Even after modeling a *pot-last* strategy, about half of the children still placed the pot on first. In mobile construction, the younger children first succeeded by starting at the bottom of the structure (Greenfield & Schneider, 1977). They started with one branch and then formed the connecting cross-piece before forming the other branch. Older children, in contrast, started at the top with the superordinate element. In the present study the pot is both the bottom element and the connecting or superordinate element. Hence, the preference to start with the pot at all ages is consistent with the tendency for younger children to start at the bottom and for older children to start with the superordinate element.

In conclusion, the present study has extended the systematic study of hierarchical organization to a new domain, two-dimensional pictures. As we hypothesized from children's spontaneous drawings, hierarchical complexity has a developmental role in the creation of two-dimensional pictures, just as in language and three-dimensional construction. Unlike earlier results with three-dimensional construction, children did not avoid interrupted strategies. Children in the whole-flower condition may not have shown a preference for either an interrupted or uninterrupted strategy because the whole-flower condition was so simple that even an interrupted strategy was within the child's information-processing limits. Second, children in the component-pieces condition showed a developmental trend toward increasing spontaneous use of interrupted strategies, just as in language and three-dimensional construction. The oldest children's preference for an interrupted strategy in this condition may result from an attempt to reduce cognitive complexity or memory load, since only the basic framework or structure needs to be remembered with an interrupted strategy.

Reference Notes

1. Greenfield, P. M., & Hubner, J. *Building tree structures at three levels of hierarchical complexity: A developmental study.* Unpublished manuscript, University of California, Los Angeles, 1977.
2. Alaniz, M. *A search for a developmental sequence in the acquisition of drawing abilities: A study of children's spontaneous drawings.* Unpublished manuscript, University of California, Los Angeles, 1973.

References

Anisfeld, M. Language and cognition in the young child. In K. S. Goodman (Ed.), *The psycholinguistic nature of the reading process.* Detroit, Mich.: Wayne State University Press, 1968.

Bever, T. G. The cognitive basis for linguistic structures. In J. R. Hayes (Ed.), *Cognition and the development of language.* New York: Wiley, 1970.

Brown, R. W. *A first language.* Cambridge, Mass.: Harvard University Press, 1973.

Elkind, D., Koegler, R., & Go, E. Studies in perceptual development: II. Part–whole perception. *Child Development*, 1964, *35*, 81–90.

Forman, G. E., Kuschner, D., & Dempsey, J. *Transformations in the manipulations and productions with geometric objects: An early system of logic in young children.* Amherst: Center for Early Childhood Education, University of Massachusetts, 1975.

Goodnow, J. J., & Levine, B. A. "The grammar of action": Sequence and syntax in children's copying. *Cognitive Psychology*, 1973, *4*, 82–98.

Goodson, B. D. The role of perception and planning in children's construction of complex block structures (Doctoral dissertation, Stanford University, 1976). *Dissertation Abstracts International*, 1977, *37*, 6367-B. (University Microfilms No. 77-12, 639)

Goodson, B. D., & Greenfield, P. M. The search for structural principles in children's manipulative play: A parallel with linguistic development. *Child Development*, 1975, *46*, 734–746.

Green, B. F. A method of scalogram analysis using summary statistics. *Psychometrika*, 1956, *21*, 79–89.

Greenfield, P. M. Structural parallels between language and action in development. In A. Lock (Ed.), *Action, symbol and gesture: The emergence of language.* London: Academic Press, 1978.

Greenfield, P. M., Nelson, K., & Saltzman, E. The development of rule-bound strategies for manipulating seriated cups: A parallel between action and language. *Cognitive Psychology*, 1972, *3*, 291–310.

Greenfield, P. M., & Schneider, L. Building a tree structure: The development of hierarchical complexity and interrupted strategies in children's construction activity. *Developmental Psychology*, 1977, *13*, 299–313.

Ingram, D. If and when transformations are acquired by children. In D. P. Dato (Ed.), *Developmental psycholinguistic theory and application.* Washington, D.C.: Georgetown University Round Table on Languages and Linguistics, 1975.

Kellogg, R. *Analyzing children's art.* Palo Alto, Calif.: National Press, 1969.

Limber, J. The genesis of complex sentences. In T. E. Moore (Ed.), *Cognitive development and the* *acquisition of language*. New York: Academic Press, 1973.

Menyuk, P. *Sentences children use*. Cambridge, Mass.: MIT Press, 1969.

Miller, P. M., Kessel, F. S., & Flavell, J. H. Thinking about people thinking about people thinking about . . . : A study of social cognitive development. *Child Development*, 1970, *41*, 613–624.

Ninio, A., & Leiblich, A. "The grammar of action": "Phrase structure" in children's copying. *Child Development*, 1976, *47*, 846–850.

Palmer, S. E. Hierarchical structure in perceptual representation. *Cognitive Psychology*, 1977, *9*, 441–474.

Piaget, J., & Inhelder, B. *The child's conception of space*. New York: Norton, 1967.

Sheldon, A. *The acquisition of relative clauses in English*. Unpublished doctoral dissertation, University of Texas, Austin, 1972.

Sheldon, A. The role of parallel function in the acquisition of relative clauses in English. *University of Minnesota Working Papers in Linguistics and Philosophy*, 1973, No. 1.

Slobin, D. I. Developmental psycholinguistics. In W. O. Dingwall (Ed.), *A survey of linguistic science*. College Park, Md.: University of Maryland Linguistic Program, 1971.

Slobin, D. I., & Welsh, C. A. Elicited imitation as a research tool in developmental psycholinguistics. In C. Ferguson & D. I. Slobin (Eds.), *Studies of child language development*. New York: Holt, Rinehart & Winston, 1973.

Vereecken, P. *Spatial development: Constructive praxia from birth to the age of seven*. Groningen, Netherlands: Wolets, 1961.

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The Publications and Communications Board of the American Psychological Association announces the appointment of Sandra Scarr as Editor of *Developmental Psychology* for the years 1981–1986. As of January 1, 1980, manuscripts should be directed to the Editor-elect:

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