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7

Structural Development in a Symbolic Medium: The Representational Use of Block Constructions

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> Over the oilcloth . . . spread towns and villages and forts of wooden bricks. . . . I could build six towers as high as myself with them, and there seemed quite enough for every engineering project I could undertake. I could build whole towns with streets and houses and churches and citadels; I could bridge every gap in the oilcloth and make causeways over crumpled spaces (which I feigned to be morasses). . . . There was the mystery and charm of the complicated buildings one could make, with long passages and steps and windows through which one peeped into their intricacies . . . .
>
> —H. G. Wells (1910)

The Development and Structure of Symbols

Representation involves a relationship between signifier and signified. A symbol (i.e., the signifier or symbolic vehicle), whether gesture, a configuration of objects, sounds, or words, serves as a vehicle for conveying the meaning that has been perceived or conceived (i.e., the signified or referent). The symbol, then, is a form that has significance by virtue of the fact that it means something. We can say that a wave of the hand represents either a salutation or a wish of farewell. Likewise, we can say that for a child a configuration of building blocks can represent a house or a road.

The emergence of representation in human development is an important part of the organism's ability to know his world (Werner and Kaplan, 1963). The development of the ability to create symbols that give form to a referent allows humans to become familiar with their environment and to communicate knowledge. Werner and Kaplan describe representation in terms of the development of four relationships: between the organism and the referent, between the organism and the symbolic vehicle, between the referent and the symbolic vehicle, and between the organism and an addressee. In childhood, these relationships can be seen to evolve from the formation of objects of contemplation (i.e., knowing an object exists even when the object is not present), to the denotation of objects (pointing to or naming objects), to the depiction of objects (recreating the object pictorially or with a construction), and then to other advanced phases of denotation (writing words, metaphor, nonfigurative symbols, etc.). In this manner, humans come to know and to express their knowledge to others.

In his discussion on the topic, Piaget (1962) presents representation in terms of the changes that occur in the relationship between signifier and signified. During the development of representation, the child progresses from index to symbol to sign; the relationship between signifier and signified in this progression becomes increasingly distant in form and time. Representation is transformed from the sensorimotor evocation of absent objects, to the accommodation (i.e., imitation) of models, to an intuitive playing with or representation of reality, then on to operational uses of symbols and signs. As with Werner and Kaplan's view of representation, the growth of symbolic functioning for Piaget is important for cognitive growth and adaptation.

Building blocks have long been recognized by educators as a symbolic medium for children. Accounts of representational block constructions can be traced to Froebel (1895), and there are many examples available that document representational block play in classrooms during the Progressive Era (Guanella, 1934; Johnson, 1974; Pratt, 1948). Current writing (Smith, 1979) and research (Reifel, 1981) provide perspective on the representational use of building blocks. Blocks are considered to be an important symbolic material for the early childhood years. Yet we know little about the various attributes of representational block use.

We do know that children's abilities to manipulate various materials relates to cognitive development, whether the materials be nesting cups (Greenfield, Nelson, & Saltzman, 1972), construction sets (Goodson & Greenfield, 1975), interconnecting straws (Greenfield & Schneider, 1977), felt pieces (Beagles-Roos & Greenfield, 1979), or

blocks (Greenfield & Hubner, n.d.; Greenfield, 1978). In research on this topic, the hierarchical complexity of constructions increases with age, suggesting that cognitive structure becomes more complex with age, at least with regard to manipulative action (Greenfield, 1978).

Hierarchical complexity is viewed in terms of the degree to which a child will replicate a physical model, a model that allows for either nesting or branching of subunits in a tree structure. The structural whole consists of parts that form a set of hierarchical relationships. Younger children are able to reconstruct branching parts of a total structure, but it is only older children who can reproduce both branching parts as well as the relationships of the branching parts to each other.

These findings relate to the work Vereeken (1961) has done on complex "constructive–praxic" behaviors (i.e., blockbuilding, copying spatial arrays, drawing, etc.). Vereeken sees the child progressing from a preconceptual stage, where parts of a total pattern are vaguely reproduced or not coordinated with the total structure, to an intuitive stage, where a configuration can be copied. A final stage includes the internal representation of the configuration, allowing for reproduction of the total form as well as for independent parts within that totality; the child can reproduce a structure using any number of strategies to recreate the various parts. Given a structure that can be viewed as hierarchically complex, such as a branching tree structure, reproduction of the complexity of the parts and of the whole become more pronounced with increasing age.

Looking at block-building activity in the classroom, Guanella (1934) documented the increasing constructional complexity of block structures. She describes a set of stages, beginning with the preorganized or nonstructural use of blocks, when children fill containers with blocks, push blocks, and hit them together. Following this stage, the child will form linear block patterns, creating either piles or rows of blocks. The third stage recognizes the bidimensional or areal use of blocks, and includes substages. The child may fill a vertical or horizontal space with blocks or create a space by forming an enclosure. An elaboration of this is the formation of a series of enclosed areas. The fourth or tridimensional stage also has substages. Solid tridimensional structures (i.e., three-dimensional piles) give way to enclosed tridimensional spaces; they may be elaborated by including parts such as openings in walls, adjacent structures, "stories" or layers of enclosures, bridges, and so on. Any of these forms can eventually be combined and augmented with decoration. The forms that Guanella describes suggest increasing complexity and possible hierarchical relationships of parts to whole, similar to Vereeken; areal enclosures are more complex than linear configurations, and tridimensional spaces are more complex than areal enclosures. The symbolic use of blocks can reflect any number of these complex structures.

It is of interest to know if cognitive principles similar to those described above apply when block structures are used symbolically. Indeed, this was the central question of our research. Given the representational character of blocks as a medium, this form of inquiry appears to be consistent with Gardner's (1979) call "to identify and map the major domains of symbolic development [p. 84]"; it would provide a description of the structural "map" that accompanies representational block play. One would expect increasing structural complexity in representational block construction with increasing age.

When discussing representation (and most other aspects of mental development), Piaget has focused on psychological development from the subject's point of view, and not from the object's point of view (Mounoud, 1976). He has been more concerned with mental structure and complexity, as opposed to the complexity or content of the objective phenomena with which children interact. He looks at what the child makes of the phenomenon rather than at how complex it is. The significance of this problem becomes apparent when we realize that children are interacting with objects and concepts that can be seen to vary in complexity. In terms of the action involved in representing a house as opposed to a tree, one would expect some recognition of the structural differences in the house and the tree. Yet, developmentally we have not attended to varying complexities of these referents. We have looked more at the child's structuring than at the objective structure of whatever is being represented.

To date, we know little about the manner in which things or ideas are depicted with blocks at different stages in development. We can comment neither about developmental changes in the structure of the signifier itself within a given symbolic medium, nor about the varying objective structural complexity of referents. These questions are pertinent to two areas of concern that have been presented above. First, it is of interest to describe the child's ability to use symbolic materials in an increasingly complex manner, and to describe the child's ability to manipulate materials in a way that reflects increasing complexity in cognitive structure. Second, it is of interest to know how the various complexities of real-world phenomena (such as houses and trees) are recognized in the child's symbolic use of materials.

Our interest began with the symbolic medium of building blocks. We have therefore tried to describe the structural principles involved in

the development of representational block play. Structural principles include such notions as differentiation of parts from the whole, and the integration at different levels of hierarchical complexity. These interests are more specifically stated in the following questions.

1. When blocks are used symbolically, do the symbols reflect a developmental progression in terms of structural complexity? That is, are children of a given age more likely to construct symbols within one level of structural complexity, with younger children creating less complex structures and older children creating more complex structures?
2. Do specific symbols (e.g., houses, paths) change structural complexity with children's development? In other words, are younger children's houses less structurally complex than older children's? Do symbols depicting more complex referents reflect developing complexity while other symbols do not?
3. Is there a developmental progression of referents per se, such that objects that have greater real-world complexity are represented more frequently by older than younger children?
4. What role do the parts of symbols play in the development of the total symbol? Are parts more salient in the symbols of older children?

In addressing these questions, we will contribute to the body of knowledge on the development of structural complexity in manipulative action. At the same time, this research takes a step toward relating structural principles to the semantic or representational aspects of action and play. Block symbols have semantic meaning for children. They represent ideas or objects that are the content of children's thinking. As in language, where grammatical and lexical structures contribute to the communication of meaning, the structural features of block constructions should also contribute to their value as symbolic communication.

One methodological aspect of this study warrants attention at this point. The study is unique in that it looks at the structures of *child-selected* symbols. Each child selected the several meanings that he or she wished to represent, within the general confines of a fairy tale. The symbols were not constructed from models that were to be imitated. In this regard, the symbols can be viewed as reflective of structures that are spontaneously generated by children at different ages. Each child selected the meanings to be represented and constructed the block configurations that were to give those meanings form. In this way, the structures that we analyze below were generated by each child alone.

Methodology

Data for our analysis were collected for a study on the development of representation in early childhood (Reifel, 1981). Forty middle-class Los Angeles children participated in the study: 20 4-year-olds and 20 7-year-olds. Each age group was evenly divided between boys and girls. The sample was ethnically mixed, but all children came from homes where English is the spoken language.

Each child was read the story of *Little Red Cap* (Grimm, 1972), a version of *Little Red Riding Hood*, then was asked to use a set of tabletop unit blocks to "Show me the story of *Little Red Cap*. You can use the blocks any way you like to show the story we just read." (The story text is presented in the Appendix.) The child could build with the blocks as long as he or she chose, with the exception of one 4-year-old who had evolved a game of set-them-up-and-knock-them-down and had to be asked to terminated his play. When construction was completed, the child was asked to describe what his or her blocks showed. In this way a complete description of the child's block symbols could be elicited. All but one of the children were eager to play with the blocks and were happy to perform the task; one 7-year-old girl seemed shy and reticent, but she eventually constructed the grandmother's house and a path for the story. A videotape record was made of all construction and of the description of block symbols. After the child left the room, a set of photographs were taken of all aspects of the block structures.

As reported in Reifel (1981), 39 of the children used the blocks symbolically; that is, they used the blocks to stand for something else. One 4-year-old boy described his constructions only as "blocks." Repeated requests for information on "What do your blocks show?" elicited only more responses of "blocks."

Two judges independently viewed each child's videotaped block play. The two judges agreed on 97% of the children's verbal labels for their block symbols. Three percent of the labels were lost as a result of inaudible audio. If the structural form of a block symbol was not clear from a photo (e.g., if it is not clear whether a three-dimensional construction is hollow), coders would review the child's construction procedures on the videotape before deciding on a coding category. The two undergraduate assistants who served as coders were initially provided photos of block constructions from books as training. They coded these photos and reached an interrater reliability of 91% by the end of training.

Coding Categories

Our interest in the hierarchical structural aspects of block symbols led us to analyze the complexity of block constructions. Earlier analyses of block constructions (Guanella, 1934; Johnson, 1974; Greenfield & Hubner, n.d.; Greenfield, 1978) suggested a set of structural features that increase in their complexity both developmentally and logically. Our coding categories built on this earlier work. Because hierarchical complexity includes the integration of new features with previously existing hierarchical structures, we refer to our primary coding dimensions as levels of hierarchical integration. These coding levels are presented in Figure 7.1 and described below.

Levels of Hierarchical Integration

LEVEL 0

At this level of construction, there is no true integration. Single blocks are used to symbolize, or blocks are simply juxtaposed by one another (e.g., rows of blocks or piles of blocks). Blocks may be added to the construction without increasing the structural complexity of the structure (see Figure 7.1).

LEVEL 1

At this level, one or more blocks in the construction are used to integrate, or to tie together, other blocks in the construction. Minimally, one block spans two other blocks. There are two sublevels within this level.

Level 1a. The most simple subtype of Level 1 is the arch or bridge. This construction can be vertical (e.g., an upright arch or bridge), or it can be horizontal (e.g., a horizontal enclosure). It may include more than one arch if the arches are on parallel planes, as in the two enclosures used to illustrate Level 1a in Figure 7.1.

Level 1b. This level adds complexity without increasing the level of integration. For the 1b level, two blocks are spanned on two nonparallel planes. It can be seen as the two blocks being arched in two nonparallel planes (e.g., a horizontal enclosure with a "roof" added) (see Figure 7.1). A nonparallel surface is being added by the child to the construction, but no new space is being integrated.

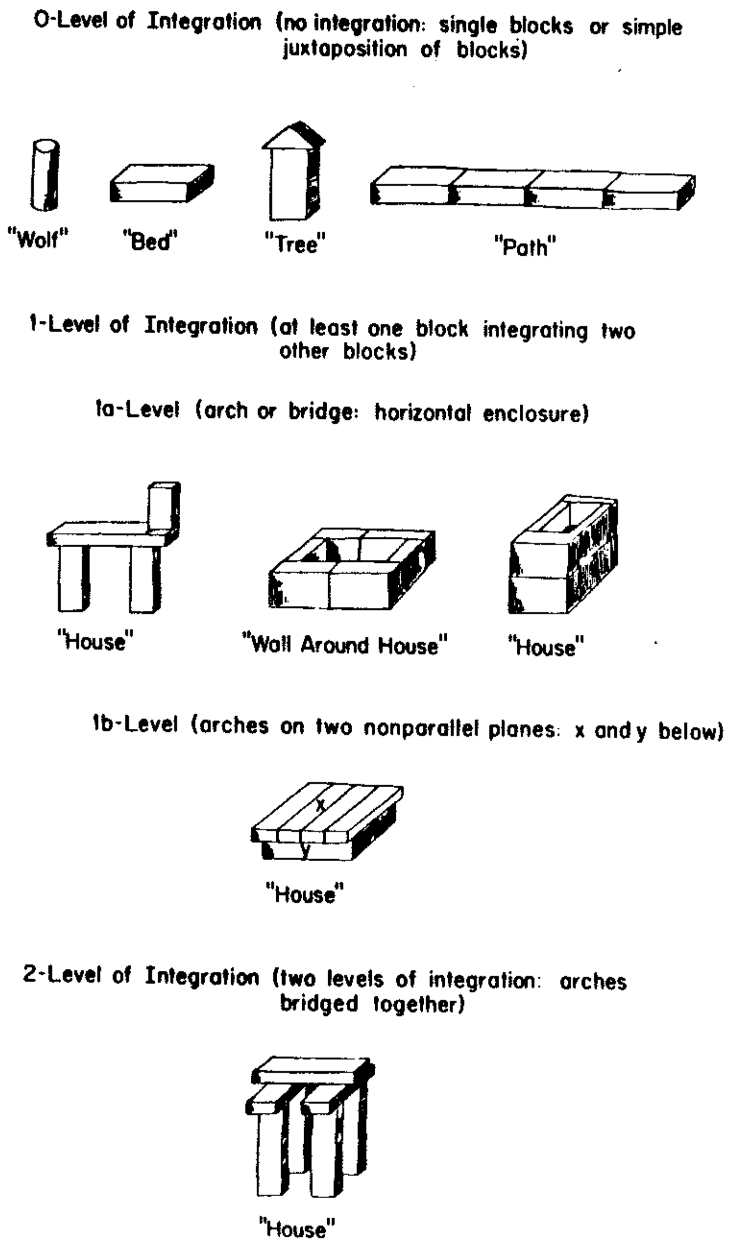

Figure 7.1. Levels of hierarchical integration.

LEVEL 2

The next level of integration is marked by two integrations. At least two arches or bridges are joined together by at least one other block, forming a bridge of bridges (see Figure 7.1). It can be seen that two Level 1a constructions are integrated by at least one block.

These three levels are not the only possible levels; there is an infinite number of possible block constructions that increase in hierarchical complexity. For example, two Level 2 structures could be joined together. These more complex levels are not being investigated here because they were rarely produced by the children.

Dimensionality

In addition to levels of integration, we were interested in other aspects of the structure of block symbols. The inherent dimensionality of blocks suggests geometric dimensionality as a relevant attribute. A system of coding block symbols was devised based on plane geometry, as follows. Each block was considered one geometric point. This is shown schematically in Figure 7.2.

NO DIMENSIONS

A symbol was considered to have no dimensions if it consisted of one geometric point. That is, if a child used one block to be a symbol, that symbol was scored as having no dimensions (see Figure 7.2).

ONE DIMENSION

A symbol was considered to have one dimension if two or more blocks were aligned in a row or pile, so that the invidiual "points" of each block formed one line (see Figure 7.2).

TWO DIMENSIONS

A symbol was considered to have two dimensions if at least three blocks were placed so as to form two lines, which is to say, one plane (see Figure 7.2).

THREE DIMENSIONS

A symbol was considered to have three dimensions if the blocks were placed to form at least one plane plus one line, which is to say at least two planes (see Figure 7.2).

Each symbol was coded both in terms of its level of integration (either 0, 1a, 1b, or 2) and of its dimensionality (no dimensions, one,

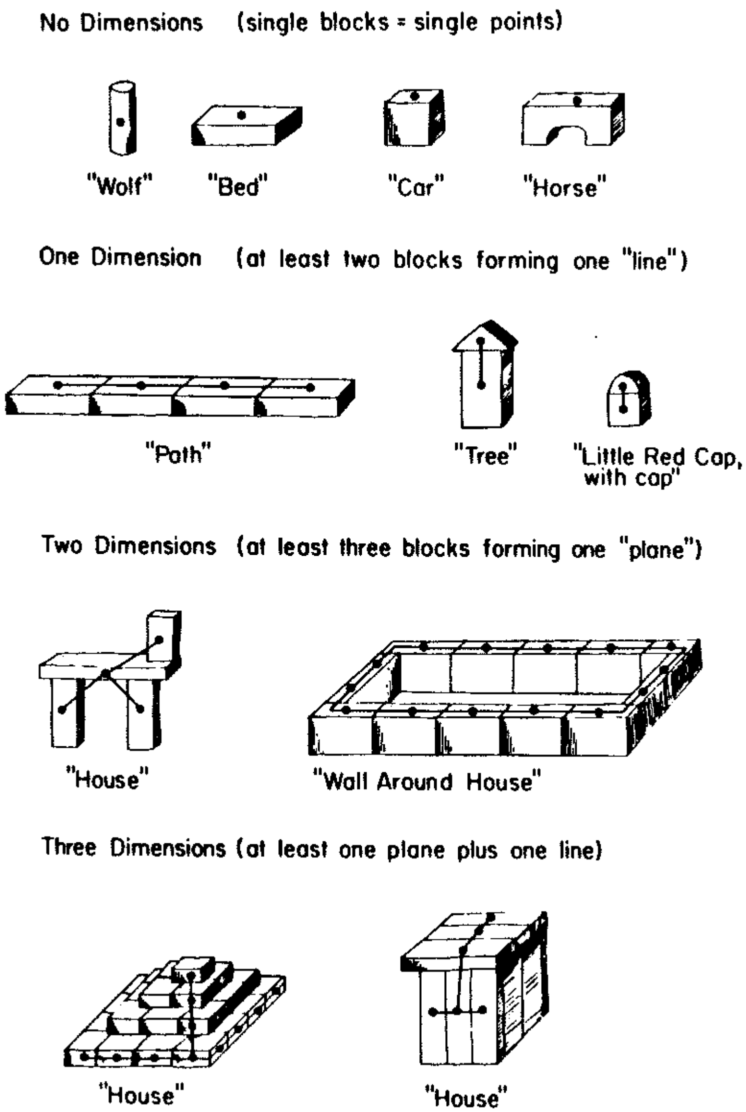

Figure 7.2. Dimensions of block structures.

two, or three dimensions). Level of integration and dimensionality are partially but not completely independent. Their relationship will be discussed in the concluding section of this chapter.

Coding Procedures

Two undergraduate assistants independently coded each symbol. They each began with a list of each child's labeled symbols, then viewed his or her photos and videotapes to determine the appropriate codes for each symbol. They achieved an interrater reliability of 86% on the study data. Because we could refer back to the photos and videotapes, we did so to review that 14% of the data for which there were disagreements. The two coders were able to resolve their coding disagreements and come to an agreement with the first author as to the true code for each contested symbol. In this way, all the children's symbols could validly be used in the analysis.

In addition, one other coder and the first author independently inspected each child's photographs in order to decide what house parts (chimneys, doors, roofs, walls, floors) could be recognized or distinguished. The coders agreed on 90% of their judgments regarding the presence or absence of those five house parts.

Results

Several analyses were conducted to ascertain the structural attributes of the block symbols and any developmental changes in structures used. First, each child's constructions were viewed in terms of the highest level of integration used by the child and in terms of the highest dimension used by the child.

Level of Integration

Table 7.1 shows that most 4-year-olds are limited, in their spontaneous constructions, to the 0-level of hierarchical integration. The great majority of 7-year-olds (85%) achieve at least the first level of hierarchical integration. In addition, the highest level of integration, while infrequent, occurs exclusively in the older age group. A chi-square analysis reveals significant age difference in level of integration ($\chi^2 = 11.08$, $p < .025$, $df = 3$), indicating that 7-year-olds do spontaneously produce higher levels of hierarchical integration than do 4-year-olds.

Table 7.1
Highest Level of Hierarchical Integration Achieved by Each Child

Level	Age 4 n (%)	Age 7 n (%)
0	12 (60)	3 (15)
1a	6 (30)	7 (35)
1b	2 (10)	8 (40)
2	0 (0)	2 (10)
Total	20 (100)	20 (100)

Table 7.2
Highest Dimension Used by Each Child

Highest number of dimensions	Age 4 n (%)	Age 7 n (%)
0	2 (10)	0 (0)
1	4 (20)	0 (0)
2	5 (25)	5 (25)
3	9 (45)	15 (75)
Total	20 (100)	20 (100)

Dimensions Used

Table 7.2 shows the highest dimension used by a child from among all of his or her symbols. The highest dimension used by the younger children is distributed across the possible range; some children were limited to symbols consisting of only one block, whereas others constructed symbols with one, or two, or three dimensions. All the older children showed a capacity to create symbols that are at least two-dimensional and most produced at least one three-dimensional structure. A chi-square test of age differences is significant at the $p < .005$ level ($\chi^2 = 13.50$, $df = 3$), indicating that older children create block symbols having more dimensions than younger children's block symbols.

Structure of Specific Symbols

In addition to the overall age differences, as reflected by the highest level of integration and the highest degree of dimensionality spontaneously produced by each child, we were interested in the structural aspects of specific symbols, such as houses and paths. Analysis of age differences in the structure of specific symbols follows. These two symbols were selected because they change with age; other symbols do not and are discussed in the final section of the chapter.

HOUSES

Tables 7.3 and 7.4 show the level of integration and dimensionality, respectively, of 4-year-olds' and 7-year-olds' houses. If a child constructed more than one house, then the most complex house was recorded here. Because of the size of the sample, low frequency cells were collapsed to allow for analysis using Fisher exact tests. For level of

Table 7.3
Houses: Level of Hierarchical Integration[a]

Level	Age 4	Age 7
0	8	4
1a	4	7
1b	2	8
2	0	1

[a] Categories below dashed line were collapsed for the Fisher Exact Probability Test.

Table 7.4
Houses: Dimensionality[a]

Highest number of dimensions	Age 4	Age 7
0	3	0
1	2	0
2	3	5
3	6	15

[a] Categories above dashed line were collapsed for the Fisher Exact Probability Test.

integration, Levels 1a, 2b, and 2 were collapsed, and the analysis reveals an exact probability of .004. The 4-year-olds' houses are less complex structurally than the houses of 7-year-olds. The 4-year-olds more often construct houses that are piles, and the 7-year-olds more often construct houses that comprise arches and horizontal enclosures.

The dimensionality aspect of the houses also reveals an age difference. After collapsing the cells for 0, 1, and 2 dimensions, the Fisher exact test reveals a probability of .05, indicating that the younger children's houses are less often three-dimensional and that the older children construct houses more often with the third dimension.

Figure 7.3 illustrates typical houses created by younger and older children. The 0-level of integration for 4-year-olds is demonstrated in

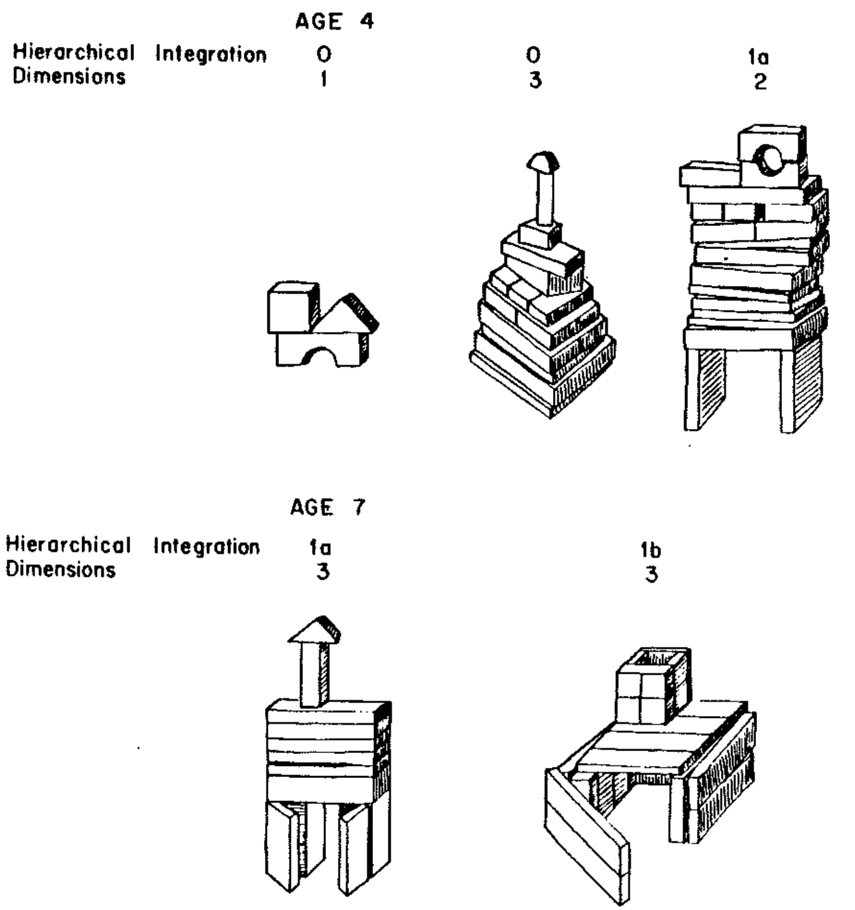

Figure 7.3. Typical houses constructed by younger and older children.

the first two drawings; the blocks are simply placed on or by each other. The second one shows a three-dimensional pile house; it has three dimensions with no hierarchical integration. The third drawing shows a more hierarchically complex 4-year-old's house, at Level 1a (an arch). In terms of our system for assessing dimensionality, this arch constitutes a two-dimensional plane, with respect to hierarchical integration. Four-year-olds' houses are not frequently more complex than the arch.

Typical 7-year-old houses in Figure 7.3 begin at the arch level. The first diagram for the 7-year-olds adds "doorway" blocks to the front of the arch, thereby making the house three-dimensional. The roof and chimney complete this house. The second 7-year-old's house diagram shows the 1b level of hierarchic integration and three dimensions. The door is tilted open, and with the three walls form an horizonal horizontal enclosure. The roof bridges the walls, so that the house consists of two nonparallel arches. The 7-year-olds' houses tend to begin at the level of the 4-year-olds' highest level of complexity, then become more complex.

It is interesting to note that there are many combinations of level of integration and dimensionality that can emerge as a house. A house at Level 0 can be one-, two- or three-dimensional. A Level 1a house can have two or three dimensions. Other combinations are possible. The style of each house seems to stem as much from the different combinations of the two features as from either feature considered in isolation. In a block symbol, the whole is definitely not the sum of its structural parts; at very least, it is its combination.

PATHS

Fourteen children constructed paths with the blocks. It appears that paths, symbolically, elicit less complex constructions than houses. This difference reflects, of course, a difference in the real-world complexity of paths and houses. There are no age differences for level of integration. Almost all children in both age groups produce paths that, like paths in the real world, are at the 0-level of integration.

The developmental picture for dimensionality is different. After collapsing cells for one and two dimensions because of small *N*'s, a Fisher exact test reveals an age difference that is significant at the probability level of .01. The 4-year-olds use a single block to symbolize the path, whereas the older children either create a linear, one-dimensional, straight path, or a meandering, two-dimensional path (see Table 7.5). Just as in the real world, there are no three-dimensional paths.

Figure 7.4 shows typical paths for each age group. The 4-year-olds use a single flat block, whereas the 7-year-olds create a one- or two-

Table 7.5
Paths: Dimensionality[a]

Highest number of dimensions	Age 4	Age 7
0	2	0
1	0	7
2	0	5
3	0	0

[a]Categories below dashed line were collapsed for the Fisher Exact Probability Test.

dimensional row. All of these symbols convey the meaning of path, visually and structurally. In the context of other block symbols, the 7-year-olds' paths are perhaps more evocative.

Complexity of the Referent

Do younger children tend to represent referents having less real-world complexity than do older children? A comparison of the frequency of paths and houses, the two most commonly selected referents that we have discussed, shows that this is not the case. Although a path has a much simpler structure than a house, there is no age difference in the relative frequency of representing the two referents. The pattern of our results indicates that the real-world complexity affects *how* but not *whether* a particular referent is attempted by the child.

Part–Whole Relations

Many of the children constructed and labeled parts of their houses, such as chimneys, doors, and roofs. This symbolic use of blocks provides a unique opportunity for looking at the development of part–

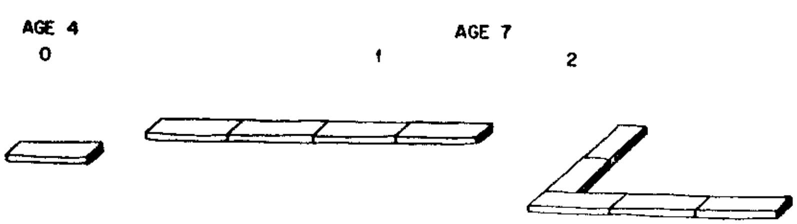

Figure 7.4. Typical paths constructed by younger and older children.

whole relationships in symbols and for considering what characteristics appear to be important for block symbols. Because the children labeled parts of their houses, we have an idea about children's (verbalized) perceptions of houses. We also have the actual constructions of houses that demonstrate structural features. Several analyses have been conducted to describe not only age differences in part–whole relationship but also to explore age differences in descriptions of part–whole features in constructed symbols.

Of the 12 4-year-olds who said they constructed houses, 10 labeled parts of them. Twenty of the 7-year-olds said they built houses, and 16 of those children labeled parts. To ascertain the actual construction of parts, we searched photos of the constructions for forms that could be recognized as chimney, door, roof, walls, and floor in each child's block house. As reported above, interrater reliability in making these identifications was 90%.

Data on the actual construction of house parts are presented in Table 7.6, alongside data on the occurrence of children's labeling of house parts. These figures provide an interesting, if irregular, picture of what house parts have been constructed and of the labels children have used to describe their houses.

The only house part that was constructed by 7-year-olds significantly more often than by 4-year-olds is doors (Fisher exact $p = .005$). Both ages were similar in the degree to which they constructed walls and floors. In terms of real-world structure, a door in the context of a

Table 7.6
Number of Children Who Labeled Specific House Parts and Who Actually Constructed House Parts

	Age 4		Age 7	
	Labeled	Constructed	Labeled	Constructed
Chimneys	6	7	8	8
Doors	4	1[a]	10	14[a]
Roofs	3[b]	7[b]	8[c]	18[c]
Walls	1[d]	11[d]	6[e]	20[e]
Floors	2	0	2	3

[a]Age difference, Fisher exact $p = .005$.
A significantly greater number constructed than labeled:
[b]$p = .08$.
[c]$p = .01$.
[d]$p = .0002$.
[e]$p = .00003$.

house consists of one structure (Level 1a) nested inside another. They differ from walls, chimneys, and floors in this respect. Just as in language, this structural characteristic of the nested or embedded hierarchy may be relatively difficult to process and may explain the lesser frequency of doors among the younger children.

Older children constructed more roofs, and younger children included more chimneys; neither difference is significant. None of the age differences for children's labels of house parts is significant.

A comparison of the figures within an age level, comparing children's labeling of constructions to their actual constructions, is informative regarding children's verbal depictions of parts of their symbols. Seven-year-olds constructed both roofs and walls significantly more frequently than they labeled them (roofs: Fisher exact $p = .01$; walls: Fisher exact $p = .00003$). Four-year-olds constructed walls significantly more frequently than they labeled the part (Fisher exact $p = .0002$), and their difference for roofs approaches significance ($p = .08$). One possible interpretation of this fact is that awareness, indexed by verbalization, lags behind the action and knowledge required for the construction itself.

In terms of house parts that were actually constructed, even if they were not so labeled, it appears that walls and roofs are relatively important for children of both ages. Doors are clearly important for older children, significantly more so than for younger children. Floors are a low priority for both ages, perhaps because the building surface provides a natural floor on which to build a house.

The analysis of parts thus far demonstrates the conscious (labeled) salience of specific parts (chimneys, doors) within constructed houses. Some specific parts emerge as more pronounced in constructions (roofs and walls), although infrequently labeled. Doors appear to develop in constructions some time between ages 4 and 7.

Another aspect of part–whole relations is the number of parts that are included in the whole house symbol. To ascertain developmental differences in the use of differentiated parts in the whole house symbol, a point score was generated for each child. Each child was given one point for each house part. A child who included a chimney, a door, and a roof as parts of his house symbol earned a score of 3. If a child constructed two houses, he was awarded ½ point for each part of both houses. Using this point system, an average score could be computed for both age groups, and the differences could be tested. This was done both for the number of parts children labeled and for the number of parts they actually constructed. Those analyses are reported in Table 7.7.

Table 7.7
Average Number of Labeled and Constructed House Parts

	Age 4		Age 7	
	Labeled	Constructed	Labeled	Constructed
$\bar{X}$	1.85	2.17	2.56	3.15
S.D.	.58	.94	.87	.75

Statistical analysis using a *t*-test reveals a significant age difference in the mean number of parts labeled by children in their house symbols ($t = 2.29$, $p < .05$, two-tailed test, $df = 24$). Older children label parts of their houses at a higher rate than do 4-year-olds.

A *t*-test reveals that 7-year-olds also construct more parts than younger children ($t = 3.27$, $p < .01$, two-tailed test, $df = 30$). This latter analysis confirms that it is not just the child's use of labels for house parts that develops; there are actually more house parts included in the constructions of older children. Children's construction of a house symbol becomes more complex with increasing age by virtue of a greater number of parts being included.

One might well wonder about how part–whole relationships in block symbols is associated with hierarchical complexity. It seems logical, from an adult perspective, that the structures of a house and its parts (as referents) require certain levels of hierarchical integration. A doorway seems intrinsically to be an arch (Level 1a) and walls with a roof seem to require a Level 1b structure. Children, however, are not limited by an adult's view of logic and have many strategies for adapting materials for their symbolic use. As a result, there is an ambiguous relationship between represented house parts and specific hierarchical structures. Some examples will illustrate.

Figure 7.5 shows two houses built by 7-year-olds. According to the child's own labels, the first house includes a "roof" (perhaps in the Mediterranean style) on top of the house, an entrance ("door"), a frame ("walls"), and a front step. Parts are represented for this house without relying on certain hierarchical structures and dimensionality that belong to real-world houses. For example, the roof does not tie together four walls. The second house in this figure includes hierarchical structures that are more complex, in an attempt to show the same parts: walls, an entrance, a roof, as well as a chimney. There is a clear difference in the structure of the symbol, but there is little difference in what parts are included by the child.

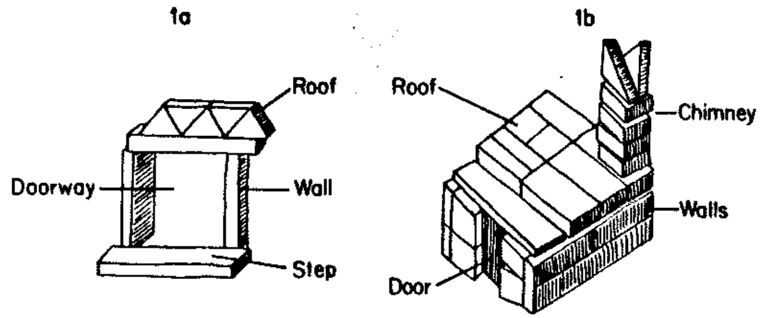

Figure 7.5. Representation of labeled house parts at two levels of hierarchical integration.

A more dramatic contrast exists between the second house in Figure 7.5 and the first house in Figure 7.3, which was built by a 4-year-old. The 4-year-old was able to take advantage of the shapes of individual blocks to represent a house with an entrance, a roof, and a chimney. This 0-level construction includes most of the parts that are part of the 7-year-old's house, without using the more advanced hierarchical complexity. These examples, while interesting, do not in any way detract from the clear developmental progression toward the use of more complex structures that we have shown above. Even if a single block will effectively stand for a referent, older children tend to take advantage of more advanced hierarchical construction patterns when they represent with blocks. This developmental change toward the use of more complex structures may well be linked with the developmental increase in the articulation of parts in symbolic wholes. What is not yet clear is whether there is a systematic developmental relationship between the structure of a referent's parts and the structure of the symbol. The materials and analyses reported here go only so far as suggesting the problem.

Discussion of Findings

The data reported above provide evidence to answer the questions that motivated our inquiry. When blocks are used symbolically, the symbols do reflect a developmental progression in terms of structural complexity. Younger children create symbols primarily with Level 0 or Level 1a of hierarchical integration, whereas older children create symbols at Levels 1a, 1b, and begin to enter Level 2 (see Table 7.1).

Block symbols do become more structurally complex with increasing age of the child.

It is important here to note that the forms we generated to define levels of hierarchical integration (see Figure 7.1) are valid in several senses. They could be used to code with a high degree of reliability. They seem to form a logical description of the development of hierarchy. They also proved to apply to all block symbols that we dealt with in this study; the forms described in the levels of hierarchical integration seem to be intrinsic to spontaneous block building.

Our second feature, dimensionality, is not entirely independent of hierarchical complexity but is related in interesting ways. For example, Level 1a (Figure 7.1) minimally requires a two-dimensional structure. It turns out, however, that dimensionality is a necessary but not sufficient component of structural complexity; 4-year-olds create three-dimensional piles that are at the 0-level of hierarchical integration. Some younger children may have facility in creating the global form of a referent with blocks (e.g., a three-dimensional house) without having the competence to make use of hierarchical structures.

There is a highly significant developmental progression in the creation of two- and three-dimensional symbols, as there is for the creation of symbols with higher levels of hierarchical integration. More inquiry is required to articulate the relationship between dimensionality and structural complexity. Both seem to be relevant for describing aspects of representational block play.

Our results show that specific symbols (e.g., houses and paths) do change in structural complexity with children's development. Four-year-olds more frequently create houses at Level 0 of hierarchical integration, whereas 7-year-olds are most frequently at Level 1a and 1b (see Table 7.3). Older children's houses are more frequently three-dimensional than younger children's (see Table 7.4). The complexity and dimensionality of house symbols progress to higher levels with increasing age of the child.

It is also interesting to note that children of both ages represent characters, trees, flowers, and beds either with a single block (e.g., a cylinder or a pillar) or with a cylinder topped with a triangle or semicircle (to form a hat, a tree top, or a flower blossom). These symbols did not change structurally with the age of the child, suggesting that the structure of these referents is not conceived differently at these ages, at least with regard to blocks as a representational medium. The same may be true for the hierarchial structure of paths; children of both ages conceive the elongated flatness of "pathness." There is no inherently greater hierarchial complexity to a path, but older children add dimensionality to their depiction. Again, the structural complexity of a representation may be constrained by the structure of the referent, as well as by the medium being used.

When referents are conceived by children as complex enough to warrant a structurally complex block symbol, parts of the symbol play a significant role in the representation of that referent. Part–whole relations in referent objects are reflected in hierarchically integrated part–whole relations in their block representations.

In addition, some particular parts emerge as significant for the whole symbol early in development. Our analyses of house parts show that from the child's perspective (from his or her labeling of house parts) chimneys, and doors are present for children of both ages. Roofs and walls, in contrast, tend to be observed by adults much more frequently than they are labeled by children. This may be because a roof and walls are taken for granted as intrinsic to a house; these parts become the inarticulated "ground" of the house rather than the salient "figure." Both door and chimney may become figure and enter verbal awareness because of the dynamic activity associated with them. In this way they contrast with the static quality of walls and roof. This tendency to verbalize the dynamic while letting what is static or constant go unsaid has been found in a number of different communication contexts (e.g., Greenfield & Zukow 1978; Greenfield & Dent, 1979; Nelson, 1973).

Basic parts of a house have varying importance for children at these ages, as reflected by the various frequencies of house parts. Floors are not very important for children at either age, perhaps because the table top serves as an implied floor for a building. Doors, a structure embedded within another structure, seem to be a significant addition to block houses between the ages of 4 and 7 (see Table 7.6). Walls appear more often than roofs and doors, for whatever reason. No matter what importance a house part may have, children's ability to construct parts of houses usually precedes their labeling of those parts.

There is development of structural complexity in children's representational use of blocks: In terms of the symbolic vehicle, this is manifested in levels of hierarchical integration they use, and in the dimensionality of symbols; in terms of the labeled referent, it is manifest in the parts that are included in whole symbols. With increasing age, children create symbols with higher levels of hierarchical integration. They also differentiate more parts in their symbols. It would be necessary to look at a sample of younger children to confirm a complete developmental picture of symbolic block structures, but other literature (e.g., Johnson, 1974) suggests that children begin block representations by using one block to stand for one symbol. (Thirty-eight of the forty children in this study created at least one symbol from only one block.) With age and experience, children progress from this stage to being able to use several blocks as a symbol, perhaps in a row or a pile. By age 4, 40% of children begin to integrate building blocks hierarchically and can put these structures to use creating houses or other complex referents. By the age of 7, 85% of children use some degree of hierarchic integration and a few even reach the highest level (Level 2) in their creation of symbols.

While a child may demonstrate a high level of hierarchical structure in one or more of his or her block symbols, many levels of hierarchical complexity are apparent in each child's constellation of symbols. Children add to their repertoire of constructional competencies, using a block structure of sufficient complexity to suit representational needs, within the developmental limits of a cognitive stage.

Parts of symbols become more salient as the child develops. It is not known whether the increasing differentiation of house symbols is due to the child's increasing ability to differentiate parts of the referent or whether it is due to an increasing ability to create more differentiated block structures, or both. What is clear is that the house symbols that older children create are more differentiated than those of the younger children, while maintaining, at the same time, hierarchical integration.

Given the child's increasing competency with block structures and (a possibly concomitant) increasing differentiation of symbol parts, it is important to return to the questions of how meaning shapes the structure of block symbols. Children with the ability to create symbols at a high level of hierarchical integration and with many parts included will still create some symbols at a more elementary level of hierarchical integration. The structure and parts of the referent may be significant (as it seems to be in our comparative analysis of house and path symbols), but the blocks themselves may impose limitations for a symbol's structural complexity. (It is not easy to build a block person with arms.) It would be relevant to take a developmental look not only at the structure of the symbol but at the child's representation of different referents in different media as well.

Our past research on the "grammar of action" (e.g., Greenfield *et al.*, 1972; Greenfield, 1978) has made the point that the development of children's manipulative constructions shows formal parallels to development in another medium, language. For example, language gains in hierarchical complexity as children grow older, just as block structures do (Greenfield, 1978). Thus simple sentences developmentally precede compound sentences, which are a concatenation of two or more simple sentences tied together by a conjunction. Compound sentences, in turn, precede complex sentences, which involve the subordination of one clause to another, adding an additional level of hierarchical complexity. The common development of hierarchical complexity in different media constitutes evidence for an underlying cognitive structure that is amodal in nature and that permits the coordination of modality-specific behavior like language and action.

The depiction of structural parallels between language and action was limited, however, by the absence of functional parallels: Language functions communicatively but the constructions we had studied did not. Language is spontaneously produced but our action tasks always involved copying a model. The present study of block symbols integrates an action medium with the creative and communicative properties of language; it therefore forms a missing link in understanding relations among cognitive development in different media. This link indicates that the structural parallels between the development of language and manipulative action go beyond mere analogy: Block symbols function like language yet develop structurally exactly like nonrepresentational block constructions.

Conclusions

The data from this study can be interpreted as consistent with Piaget's structural theory (Piaget, 1971; Greenfield, 1978) as well as a corroboration of earlier empirical work on hierarchical complexity (Greenfield, 1978; Guanella, 1934; Vereeken, 1961) that builds on not only Piaget's theory, but also Werner's (1948) developmental theory. These data also expand on that earlier work in a number of ways. First, we have demonstrated the development of hierarchical structure in spontaneously created block constructions. (This finding partially replicates Guanella's [1934] naturalistic observations of classroom block construction.) Second, this set of findings is further significant because we analyzed block symbols, that is constructions that have representational meaning. Several of these symbols (houses, paths) change structurally with the child's age. Third, we have shown that differentiated parts of a symbol and its referent do have contributory roles as the child constructs the whole symbol; older children include more parts in their construction of houses, a relatively complex real-world referent whose parts are well adapted to the medium of blocks.

It is clear from our data that the hierarchical structure of block symbols develops with age. Assuming that the hierarchical structural elements of a child's activity with a constructive medium reflects the child's cognitive organization, it is apparent that block symbols reflect a child's level of cognitive development. Younger children do not create block symbols that are as hierarchically complex as those of older children. The cognitive organization of symbolic structure appears to develop, becoming more hierarchically integrated with age (Werner, 1948). Inasmuch as the levels of hierarchical integration that we have defined can be viewed as stages of cognitive growth, there is a developmental progression in stages. Few of the younger children create any symbols at Levels 1a and 1b, and none created any at Level 2 (see Table 7.1). Nearly all of the older children achieved Level 1a or 1b, and two older children entered Level 2.

This increasing hierarchial complexity in spontaneous block symbol structures seems to parallel the structural development that has been documented in nonrepresentational action (e.g., Greenfield, 1978), including block construction (Greenfield & Hubner, n.d.; Greenfield, 1978), and in the copying of two-dimensional pictures (e.g., Beagles-Roos & Greenfield, 1979). Hierarchical organization is present in spontaneous symbolic block construction, in the form of increasing levels of hierarchical integration and in the inclusion of more parts in a symbolic whole. Younger children create symbols of lower levels of hierarchical integration and with fewer parts in some cases. Older children create symbols that are more differentiated and that reflect higher levels of hierarchical integration.

The block structures under investigation tell us not only about the development of hierarchical complexity and dimensionality. Because the structures are block symbols, they are informative regarding the development of symbolic functioning. Children's symbols increase in their complexity as children grow older, even though children retain and use their abilities to create less complex block symbols. With a child's increasing age, symbols of houses tend to reflect more of the complexity of the referent, using hierarchically integrated structures to represent differentiated parts of the referent.

There is an interaction between the development of cognitive structure and the structure of the referent. Older children create complex symbols to represent structurally complex referents like a house and simple symbols to represent structurally simple referents like a path. Another aspect of the interaction between cognitive structure and structure of a referent is that younger children simplify complex referents rather than avoid representing them at all. This lack of avoidance confirms Piaget's emphasis on the structure of the subject rather than the structure of the object. However, the fact that complex symbols are created only in response to complex referents shows that the structure of the object must also be taken into account in assessing a child's capacity to construct a complex symbol.

The various structural features that we have demonstrated in our analysis provide one view of symbolic play. At the same time, there is a quality to the block constructions that clearly goes beyond the individual analytic features of level of hierarchical integration and dimensionality. The block structures clearly refuse to be reduced to two features. Within each structural type there is a wealth of aesthetically interesting variation. And as interesting as the features are considered one at a time, the ways level of integration and dimensionality are combined are more fascinating still.

Neither level of integration nor dimensionality conceptually treats one single element in isolation. Both variables are structural concepts insofar as they describe relationships among blocks rather than individual blocks in isolation. Yet even structural analysis abstracts from the richness of a concrete symbol. Because level of integration and dimensionality are analytic concepts, they strip away the detailed complexity of the real world. Our analysis therefore causes us to lose sight of the very thing that is most striking about these block symbols: They are creative masterpieces of the first order.

But, as with the infinite creativity of language, the unique and original block symbols of children may be produced through the operation of a finite set of generative rules. The structural principles identified in our analysis—level of hierarchical integration and dimensionality—may function in just this way, as generative rules capable of creating an infinite set of symbolic constructions, as Figures 7.6 and 7.7 suggest.

Appendix: Little Red-Cap[1]

Once upon a time there was a dear little girl who was loved by everyone who looked at her, but most of all by her grandmother, and there was nothing that she would not have given to the child. Once she gave her a little cap of red velvet, which suited her so well that she would never wear anything else; so she was always called "Little Red-Cap."

[1]From The Complete Grimm's Fairy Tales, by Jakob Ludwig Karl and Wilhelm Karl Grimm, translated by Margaret Hunt and James Stern. Copyright 1944 by Pantheon Books, Inc. and renewed 1972 by Random House, Inc. Reprinted by permission of Pantheon Books, a Division of Random House, Inc.

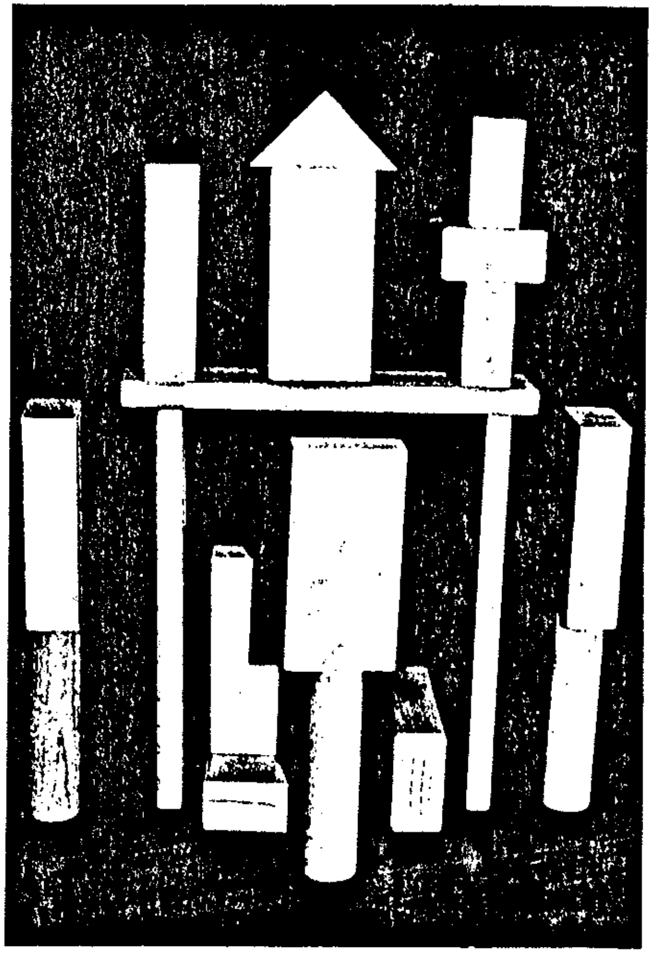

Figure 7.6

One day her mother said to her: "Come, Little Red-Cap, here is a piece of cake and a bottle of wine; take them to your grandmother, she is ill and weak, and they will do her good. Set out before it gets hot, and when you are going, walk nicely and quietly and do not run off the path, or you may fall and break the bottle, and then your grandmother will get nothing; and when you go into her room, don't forget to say, 'Good-morning,' and don't peep into every corner before you do it."

"I will take great care," said Little Red-Cap to her mother.

The grandmother lived out in the wood, a little way from the village, and just as Little Red-Cap entered the wood, a wolf met her. Red-Cap did not know what a wicked creature he was, and was not at all afraid of him.

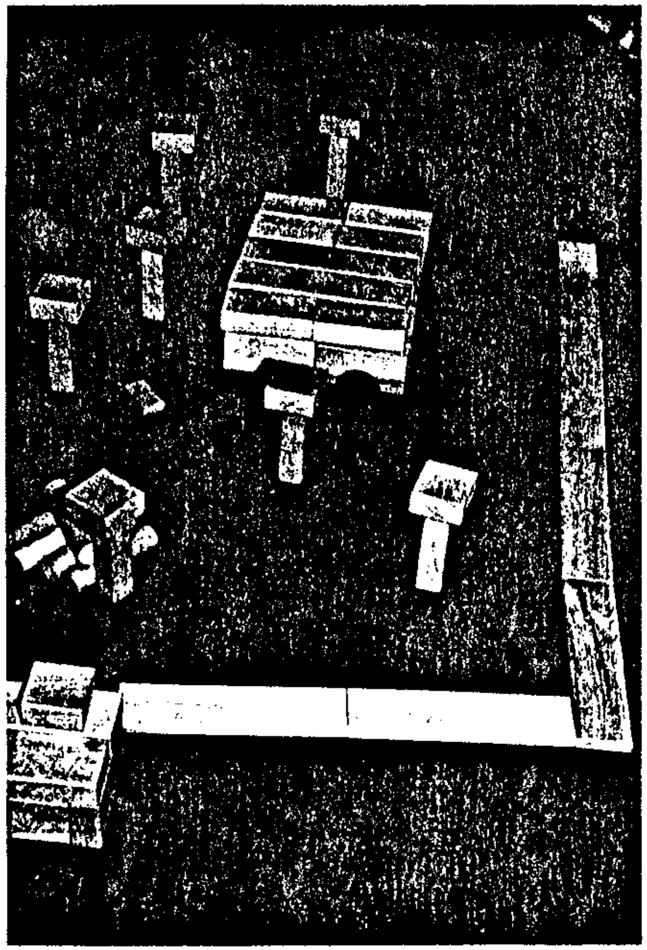

Figure 7.7

"Good-day, Little Red-Cap," said he.

"Thank you kindly, wolf."

"Where are you going so early, Little Red-Cap?"

"To my grandmother's."

"What have you got in your apron?"

"Cake and wine; yesterday was baking-day, so poor sick grandmother is to have something good, to make her stronger."

"Where does your grandmother live, Little Red-Cap?"

"A good quarter of a league further on in the wood; her house is under the three large oak-trees, the nut-trees are just below; you surely must know it," replied Little Red-Cap.

The wolf thought to himself: "What a tender young creature! What a nice plump mouthful—she will be better to eat than the old woman. I must be careful, so as to catch both." So he walked for a short time by the side of Little Red-Cap, and then he said: "See, Little Red-Cap, how pretty the flowers are about here—why do you not look around? I believe you do not hear how sweetly the little birds are singing; you walk as if you were going to school, while everything else out here in the wood is happy."

Little Red-Cap raised her eyes, and when she saw the sunbeams dancing here and there through the trees, and pretty flowers growing everywhere, she thought: "Suppose, I take grandmother a fresh bunch of flowers; that would please her too. It is so early in the day that I shall still get there in good time"; and so she ran from the path into the wood to look for flowers. And whenever she had picked one, she saw a still prettier one farther on, and ran after it, and so got deeper and deeper into the wood.

Meanwhile the wolf ran straight to the grandmother's house and knocked at the door.

"Who is there?"

"Little Red-Cap," replied the wolf. "She is bringing cake and wine; open the door."

"Lift the latch," called out the grandmother, "I am too weak, and cannot get up."

The wolf lifted the latch, the door sprang open, and without saying a word he went straight to the grandmother's bed, and ate her up. Then he put on her clothes, dressed himself in her cap, laid himself in bed and pulled up the covers.

Little Red-Cap, however, had been running about picking flowers, and when she had gathered so many that she could carry no more, she remembered her grandmother, and set out on the way to her.

She was surprised to find the cottage-door open, and when she went into the room, she had such a strange feeling that she said to herself: "Oh dear! I feel uneasy to-day, and at other times I like being with grandmother so much." She called out: "Good morning," but there was no answer; so she went to the bed and drew back the covers. There lay her grandmother with her cap pulled far over her face, and looking very strange.

"Oh! grandmother," she said, "what big ears you have!"

"The better to hear you with, my child," was the reply.

"But, grandmother, what big eyes you have!" she said.

"The better to see you with, my dear."

"But, grandmother, what large hands you have!"

"The better to hug you with."

"Oh! but, grandmother, what a terrible big mouth you have!"

"The better to eat you with!"

And scarely had the wolf said this, then with one bound he was out of bed and swallowed up Red-Cap.

When the wolf had appeased his appetite, he lay down again in the bed, fell asleep and began to snore very loud. The huntsman was just passing the house, and thought to himself: "How the old woman is snoring! I must just see if she wants anything." So he went into the room, and when he came to the bed, he saw that the wolf was lying in it. "So I find you here, wolf!" he said. "I have been looking for you!" Then just as he was going to shoot his gun, it occurred to him that the wolf might have eaten the grandmother, and that she might still be saved, so he did not shoot, but took a pair of scissors, and began to cut open the stomach of the sleeping wolf. When he made two snips, he saw the little red cap shining, and then he made two snips more, and the little girl sprang out, crying: "Oh, how frightened I have been! How dark it was inside the wolf"; and after that the old grandmother came out alive also, but hardly able to breathe. Red-Cap quickly brought big stones with which they filled the wolf's stomach, and when he awoke, he tried to run away, but the stones were so heavy that he collapsed at once, and fell dead.

All three were happy. The huntsman took off the wolf's skin and went home with it; the grandmother ate the cake and drank the wine that Red-Cap had brought, and felt better, but Red-Cap thought to herself: "As long as I live, I will never leave the path, to run into the wood, when my mother has told me not to do so."

Acknowledgments

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