Transitions in Early Representational Intelligence: Changes over Time in Children’s Production of Simple Block Structures

SUSAN SUGARMAN

A major transition occurs in the second year of life with the emergence of representational intelligence. Children begin to reflect on their actions and perceptions and form symbolic relations between things. This transition has been well documented, and a considerable convergence of findings exists (e.g., Bates, 1979; Bornstein & Kessen, 1979; McCall, Eichorn, & Hogarty, 1977; Piaget, 1962, 1963; Werner & Kaplan, 1963). Subsequent changes in representational intelligence (ca. 2–3 years), by contrast, have been sparsely researched (Campbell, 1979), and somewhat contrary implications may be drawn from what is known about this period.

The consensus of the traditional theorists is that little, if any, structural reorganization occurs in early representational thought beyond the attainment of initial milestones (e.g., first words or word combinations, symbolic play, prolonged search for objects hidden and displaced several times). Early representational thought is believed to re-

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main under the dominance of sensorimotor intelligence. It "oscillates between purely motor and figural characteristics (Piaget & Inhelder, 1967, p. 17; see also Bruner, 1966; Werner, 1948)."

That early representational thought reflects the established tendencies of sensorimotor intelligence is undeniable. This account may overlook certain discontinuities, however. Children begin to talk by 1½ years of age, when they have begun to exhibit other signs of representational intelligence, but their language changes dramatically in form and content by the time they reach 2½ or 3 (Bowerman, 1978a). While sensorimotor intelligence may constrain early language (e.g., Brown, 1973; Edwards, 1973), the influence of sensorimotor intelligence cannot account for the reorganization apparent in language by the middle of the third year (Dore, 1979; Sinclair, 1971; Slobin, 1981).

These discontinuities could be specific to language. Indeed, the inadequacies of sensorimotor intelligence in accounting for language are usually attributed to language being a "peculiarly specialized form of representation [Slobin, 1979, p. 1]." Also, universal features of cognition (such as sensorimotor intelligence) cannot account for the variation across the different languages children learn (Slobin, 1979). Some aspects of language development, however, may reflect general properties of developing representational intelligence, properties of a mind distancing itself farther and farther from the control of immediate stimulation.

Consider the following observations of language change. The earliest linguistic forms children acquire tend to express meaning directly; within a year or so the mapping from meaning to form becomes increasingly indirect (Slobin, 1973). Children begin to link superficially disparate linguistic forms at a deeper level (e.g., Bowerman, 1973; Karmiloff-Smith, 1979). From another perspective, the internal structure of external forms develops in complexity (Bever, 1970; Bloom 1970).

I shall argue that an analogous process of distancing between internal structure and external form takes place between thought and action during the same period (1½ to 3 years of age).2 The mapping from thought, or "internal structure," to sequences of action, or "external form," becomes increasingly elaborate as children's conceptual schemes develop in complexity. The basis for the present argument is a detailed analysis of 1-3-year-old children's procedures for constructing two types of arrangements in manipulative classification tasks. Changes in the way children produce superficially similar arrangements imply qualitative changes in the way they conceptually structure the array with which they are engaged. By the middle of the third year children are simultaneously coordinating relations they were imposing on arrays only seriatum during the second year.

The Study

Analytic Strategy

The investigation consisted of analyses of 1-3-year-olds' spontaneous and elicited manipulation of sets of two classes of objects, with four objects in each class—for example, four blocks and four toy plates. Two-class sets were selected both because they had previously been found to elicit organized activity from children between 1 and 3 years (Fischer & Roberts, 1979; Nelson, 1973; Ricciuti, 1965) and because such sets would limit the range of configural arrangements children were likely to produce, thus enabling comparisons of different children. As will become clear, arrays containing only two classes of objects nevertheless allow sufficient latitude in organization to suggest a series of qualitative advances in the way children conceptually order things.

The most critical requirement of the study was to distinguish between classificatory behavior, or classificatory forms, and the conceptual organization behind that behavior. The distinction between surface form and underlying organization has had considerable consequence for understanding the nature of change in language development. At different points in development the same surface forms (e.g., sentences) may be motivated by different underlying structure (e.g., Bowerman, 1973). There is no reason, in principle, why the same variation in underlying structure should not exist in classificatory manipulations.

Previous studies of early classification have not distinguished between surface form and underlying organization; this may contribute in part to the impression that little conceptual change occurs during the early representational period. Moreover, although admittedly not usually addressed to underlying organization, the earlier studies pro-

2It should be noted that a trend toward an increasing dissociation of action and thought, coupled with developing internal structure, is embodied in a general way in traditional accounts of cognitive development (Inhelder & Piaget, 1964; Vygotsky, 1962; Werner, 1948). The traditional theories extend that trend over 7 or 8 years, however, whereas the proposed account postulates a subtler trend extending from 1 to 3 years of age. Consistent with the proposed trend, some Soviet writers acknowledge the early, if limited, reorganizing and regulating influence of representation on behavior (Luria, 1961; Poddya'kov, 1974; Vygotskly, 1978). That work is not elaborated here since it emphasizes the regulating influence specifically of language, rather than of representation in general. The Soviet work also does not emphasize underlying cognitive organization, of principal interest here.
ceeded in ways that preclude assessment of underlying organization in retrospect.

These initial studies identified units of class-consistent organization as an endpoint of investigation. The units include, for example, spatial groupings of several objects from one or two classes (e.g., a pile of four blocks and a pile of four plates), or sequential handling of several objects from one or two classes, whether or not those objects end up spatially grouped (e.g., manipulating, in turn, four discrete blocks, and then, in turn, four discrete plates). By themselves, however, these forms cannot specify the conceptual organization that led to their construction. The same spatial arrangement, or the same temporal sequence of object manipulations, produced by different children may reflect different conceptual organization of the objects (Sugarman, 1979), just as solutions to most problem-solving tasks may be reached through different levels of understanding of the problem (Werner, 1937).

Conversely, superficially dissimilar forms may reflect the same or similar conceptual organization. Objects may be organized by class even if they are not arranged specifically in class groups. For instance, rather than producing a row of dolls and a separate row of rings, a child might establish a functional relation between the classes by placing a doll inside every ring in one-to-one correspondence (see Figure 3.1). As in the case of class groupings, the final (correspondence) array may reflect a different conceptual organization on different occasions. A given correspondence construction may have more in common concep-

![Figure 3.1](image)

**Figure 3.1.** (A) Class grouping and (B) one-to-one correspondence between classes.

tually with a given class grouping than with another correspondence construction.

To permit close assessment of the conceptual organization entailed in children’s object ordering activities, the present analysis works retrospectively from units of class-consistent organization to the way in which each unit was produced. On appropriate occasions, the analysis also takes into account larger (e.g., task-wide) trends in object manipulation of which the unit in question may be a part. Following psycholinguistic investigations (see Bowerman, 1973), the analysis then infers from a child’s activity pattern the conceptual organization minimally required to generate that pattern. It does not assume the organization that might generate the pattern in, say, adult performance.

To test the generality of the trends found, the two outwardly different forms of classification noted above, class groupings and between-class correspondence constructions, were both studied.

**Method**

Forty children were tested, eight each at 12, 18, 24, 30, and 36 months. Age cohorts were evenly divided by sex. Families were living in the vicinity of Oxford, England, at the time of testing.

Each child was presented with the same seven sets of materials. Each set contained two classes with four items in each class. Sets varied so as to facilitate production of class groupings or one-to-one correspondences. Set's designed to encourage correspondence construction permitted containment of one class by the other—for example, dolls and rings, spoons and cups. Children at the ages tested like to contain things (Bower, 1974; Gesell & Thompson, 1934; Piaget, 1971). Sets permitting containment should thus encourage combination of objects by dissimilarity—for example, putting a doll in each ring, yielding, in turn, a correspondence between the classes. Sets not permitting containment (e.g., blocks and plates, cylinders and columns) were used to encourage grouping by class. Such sets facilitate class grouping insofar as they do not specifically encourage combining objects by dissimilarity. As will be seen, the materials were effective in eliciting the two desired forms of organization at each age. It should be noted, though, that during spontaneous play children were free to construct either form in any task, and often did so, such as placing a block on every plate (correspondence in a noncontainment task), grouping the dolls and rings separately (class grouping in a containment task).

Each child was tested in a playroom at the University of Oxford. One or both parents accompanied the child. Each of the seven tasks began
with a 2½-minute spontaneous play period in which the objects were presented in a scrambled array, with the instruction, “These are for you to play with.” The spontaneous play phase of two noncontainment tasks was followed by two elicitation probes involving class grouping, and two containment tasks were followed by an elicited correspondence probe. These probes will be described in what follows.

All sessions were videotaped. After subjects’ sequential maneuvers had been thoroughly transcribed (see Sugarman, forthcoming), spontaneous behavior was segmented into individual constructions. Two criteria determined the bounds of an individual construction: (a) spatial contact or close proximity of two or more objects, and (b) preservation of the same spatial order of objects within the construction, provided no deletions of objects occurred. That is, as long as the child continued to add objects to a construction without changing the order of any of those objects already present, only one construction was scored. Each construction was subsequently scored for its static class properties (e.g., one class grouped, two classes grouped, one-to-one correspondence, mixed) and for the order in which objects in different classes were added to the construction (e.g., only one class placed, two classes placed one at a time, two classes placed in mixed order). Thus the unit of analysis in spontaneous behavior was drawn from the behavior itself, not from an externally circumscribed trial (as in the elicitation probes), or from the boundaries of the task, or from an arbitrary chunking procedure like time sampling. Procedures for scoring the static class properties and construction procedures of elicited constructions were modeled after those used in the analysis of spontaneous data.

**Background Data**

Before turning to the development of specific kinds of constructions, it is worth noting some general quantitative trends in subjects’ spontaneous activity. Like mean utterance length in language studies (see, e.g., Brown, 1973), these trends anticipate qualitative changes while not, of course, specifying the exact nature of those changes.

The number of constructions subjects produced spontaneously was constant across age (mean = 52, range of age group means = 45–59). Therefore, any trends emerging from these data are not the artifact of a changing base rate of activity.

The number of objects children combined in one construction (of any type) increased significantly between 1 and 3 years of age. The proportion of constructions organized consistently by class (class groupings or correspondences) also increased. However, the overall increase in class-consistent organization is accounted for by changes in larger, rather than smaller, constructions (see Table 3.1). Furthermore, a reversal occurred in the relation between size and consistency as age increased. The 12-month-olds showed a higher rate of consistency when producing constructions of two to four objects than when producing constructions of five to eight objects. The gap in consistency between size ranges disappeared by 24 months and widened again at 30 and 36 months, when large constructions were more likely than small ones to be class-consistent (Table 3.1).

These trends show that with increasing age children impose a consistent organization on increasingly large numbers of objects and that this development is not simply synonymous with producing larger constructions. One possible explanation of this development is that children bring to their organizational activities increasingly powerful conceptual strategies. The following sections explore this possibility.

### The Development of Class Grouping

To obtain a sensitive measure of the conceptual strategies of the youngest (12-month-old) children, it is necessary to digress from the consideration of spatial constructions to look solely at the order in
which children contacted different objects. Previous investigators have found greater consistency in the order in which 1-year-olds select objects than in the order in which they arrange objects spatially (Nelson, 1973; Ricciuti, 1965). In the present study as well, space did not appear to serve as a locus of organization for 1-year-olds. For example, most of the spatial constructions they produced resulted from the manipulation of a single object in relation to one or two other objects, rather than from the collection of many objects in one place (see Greenfield, Nelson, & Saltzman, 1972, for a related finding). Accordingly, the first subsection below examines patterns in children’s sequential manipulations without regard for the spatial arrangements resulting from these manipulations.

**Trends in Spontaneous Object Selection**

Previous work has shown that children as young as 12 months will sequentially touch or pick up four objects of one kind when presented with a mixed array of two classes—for example, picking up four dolls, in turn, from a mixed array of dolls and rings (Nelson, 1973; Ricciuti, 1965; Starkey, 1979). There is some suggestion, however, that at this age sequential selection of similar objects coincides with a preference for one of the two classes in the array; preference is indicated by a sample-wide tendency to select from the same class on the first move in a given task (Ricciuti, 1965; Starkey, 1981). Association of the sequential selection of similar objects with a preference for one class could have substantial implications for the way in which a child is conceptually interrelating the similar objects he or she selects. In successively contacting similar objects the child might be selecting what is salient, rather than comparing the objects with one another in a search for something that “looks like” something else. Suppose, however, a child sequentially selects several things that look the same, but has no preference for either class. That child’s selections could not be explained by the perceptual salience of a particular class of objects. This child is more likely than the first to be comparing the objects with one another, looking for the “same kind of thing,” in order to make selections.

These two very different cognitive strategies can be distinguished reasonably well by an exhaustive analysis of children’s sequential selections of objects. Such an analysis was performed in the present study in two phases. First, all tasks were identified in which children selected similar objects in sequence more than chance would predict. The number of such tasks did not vary significantly with age. The proportion of selections involving each class was then determined in each task identified in the first phase. For example, if a child selected similar objects in sequence above chance level in the doll and ring task, the proportion of moves involving dolls and the proportion involving rings was then determined.

The 12-month-olds selected similar objects in sequence only if they were manipulating objects from one class on at least 75% of the moves in that particular task—for example, selecting dolls three-quarters of the time when both dolls and rings were available, and thus selecting “similar” objects. With increasing age, children were able to select objects by similarity while handling items from the two classes with increasingly equal frequency—for example, selecting similar objects while selecting dolls approximately half the time and rings the other half.

The younger children’s ordering was even more restricted than these results suggest. The 12- and 18-month-olds not only selected predominantly from one class when contacting similar objects, but they all selected the same class—for example, dolls in the doll-and-ring task, plates in the plate-and-block task, and so on. This finding supports the determinative role of object salience in early selection by similarity. On occasions when the older (24- to 36-month-old) subjects chose heavily from one class in a given task, they favored either class—that is, one child at a given age might select dolls most of the time, whereas another child the same age might select rings.

The combined findings indicate that 1- to 3-year-olds’ sequential selection of similar objects becomes progressively less dependent on the salience of individual items. Additional analyses showed noticeable progress in this direction within the second year. This trend suggests the emergence, or increased dominance, of conceptual comparisons of the items being ordered, that is, a strategy whereby, at the very least, a child locates one thing, looks for something like it, looks for something like that, and so on.

**Grouping Objects in Space**

Once children can be said to be conceptually comparing the items in an array, the questions arise of how much structure they impose on the array and how this structuring subsequently develops. One potential indication that changes in conceptual structuring continue to occur is that the sequential selection of similar objects became still less associated with manipulation of one class after 2 years than it was at 2 years. The analysis of spatial class grouping permits more specific inferences than the foregoing analysis about conceptual structuring during this later period.

All children spontaneously grouped together similar objects, and
did so with roughly the same frequency. The composition of these groupings and, in particular, the way in which they were produced, changed.

Groupings containing objects from two classes (e.g., a pile of blocks next to a pile of plates), as opposed to objects from only one class (e.g., a pile of blocks, with plates ungrouped), increased significantly with age. At 12 and 18 months, two-thirds of subjects’ groupings contained one class, whereas at 24, 30, and 36 months one-half to two-thirds contained two classes.

While the products observed from 24 to 36 months were similar, the procedures yielding them were not. All children between 12 and 24 months produced two-class groupings in only one way. (NB: All subjects at each age produced at least one two-class grouping.) They arranged the classes one class at a time.

**MH, 24 months:** *M drew four dolls together into a square formation. Next he stacked the four rings in his hand. He then separated the rings into two groups on the table, and then drew them together.*

Half the 30- and 36-month-olds produced two-class groupings another way. They shifted between classes as they grouped them.

**NH, 30 months:** *N stacked two plates on the table. Next she stacked two blocks together. Then she added two plates to the plate stack. She then rearranged the blocks into an alignment and added the third and fourth blocks to them.*

An elicitation probe was introduced to examine whether the younger children could use this shifting procedure if encouraged to do so. The experimenter placed an exemplar of each class on the table—for example, a block and a plate—several inches apart. She then handed the child the remaining six objects in a mixed-class order: a-b-a-b-a- or a-b-a-b-b-a. Fourteen (of 24) children between 24 and 36 months carried out the shifting procedure in grouping classes under these circumstances. However, they were mainly children who had used the procedure spontaneously. More interestingly, several 18- and 24-month-old children made efforts to group the objects, but grouped them one class at a time—for example, by accepting only one class from the experimenter—and batting items from the second class out of the way as they were presented.

Thus the younger children persisted in organizing classes one at a time, even when confronted with a condition that did not facilitate that procedure. When prompted, the older children readily shifted between classes while grouping, especially if they had done so spontaneously.

The difference in manipulative procedure suggests a difference in conceptual strategy. In order to group one class only, or two classes one at a time, children need to keep only one type of thing in mind: They locate one thing, look for something else like it, look for something like that, and so on. They must also be able to discard objects that do not belong to the class being formed, but they need not immediately reclassify those items with some other group. Children grouping two classes in tandem, however, take an object and decide with which of two groups that object belongs. An item judged not to belong in one group is considered as a possible member of another group; it is not simply rejected.

Both procedures, then, involve a comparison of individual objects on the basis of their similarities and differences: Is *x* like *a* or not? The shifting-classes method of grouping, however, implies a coordination of these comparisons: What is not like *a* is (or may be) like *b*.³

The hypothesis that the older children were coordinating classes was further corroborated by a second probe. The experimenter presented a partially grouped array: Three items from each class were grouped with one item from the other class. When told to “fix it up,” the 2½- and 3-year-olds immediately lifted and reversed the two misplaced objects. Younger children who corrected the array did so by arranging all the objects one class at a time, as they had done when presented with the scrambled arrays in spontaneous play.

In summary, it appears that children between 1 and 3 years conceptually structure the same input to different degrees, even though their output (of spatial groupings or sequential selections) may be the same. During the second year, class grouping progresses from being based on a stimulus-bound organization of objects to an organization involving conceptual comparisons of individual objects in terms of their similarities and differences. During the third year, it becomes based on a coordination of such comparisons.

### The Development of One-to-One Correspondence between Classes

The study of correspondence constructions provides an interesting test of the generality of the trends we see in class grouping. Unlike

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³The presence of only two classes leaves open the possibility that children shifting between classes while grouping are classifying objects as the “*A*s” and “the other ones,” rather than as “*A*s” and “*B*s.” Subsequent research shows, however, that 2½-3-year-olds shift as easily among three or five classes when grouping as they do between two classes, particularly when prompted (Sugarman, in preparation).
Trends in Early Representational Intelligence

Two kinds of extraneous moves appeared in the 12-month-olds' construction of correspondences. First, the children would move a single object from place to place, thereby precluding the immediate accrual of several subunits:

IK: 12 months
He put spoon 4 in cup 4.
He put spoon 3 in cup 3.
He put spoon 2 in cup 2.
He put spoon 1 in cup 1.

The second kind of extraneous move involved transactions between objects in the two classes. Rather than only one class—spoons or cups—being involved in the transaction, both classes were in contact with each other, as with the above example: spoon 1 to cup 1; spoon 2 to cup 2; spoon 3 to cup 3; spoon 4 to cup 4. This type of extraneous move was more frequent than the first type. The second type of transaction was of particular interest, since it involved a transaction between two classes. The class in the transaction was not the same class as the class of the recipient of the item. The second type of transaction was not a simple exchange of items, as in the first type. The second type of transaction was more complex, involving a transaction between two classes.

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While correspondence construction continued to be indicated at 18 months, the interruptions that occurred involved systematic treatment of the two sets of objects. The children did not sequentially pick up different class elements, and they did not place objects in the same place as the other objects. Rather, they would pick up one item of one class, and then place it in the same place as one item of the other class. For example, they would pick up a spoon from one class, and then place it in the same place as a spoon from the other class.

CS: 18 months
C put block 1 on plate 1.
C put block 2 on plate 2.
C put block 3 on plate 3.
C put block 4 on plate 4.
C put block 5 on plate 5.
C put block 6 on plate 6.
C put block 7 on plate 7.
C put block 8 on plate 8.
C put block 9 on plate 9.
C put block 10 on plate 10.
C put block 11 on plate 11.
C put block 12 on plate 12.
C put block 13 on plate 13.
C put block 14 on plate 14.
C put block 15 on plate 15.
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C put block 92 on plate 92.
C put block 93 on plate 93.
C put block 94 on plate 94.
C put block 95 on plate 95.
C put block 96 on plate 96.
C put block 97 on plate 97.
C put block 98 on plate 98.
C put block 99 on plate 99.
C put block 100 on plate 100.
This child picked up a new block right after placing another block (on a plate). But as she encountered each new block she took it first to a location at which she had already placed a block, and only then located an unused plate on which to put it. Similar episodes occurred in which children would go so far as to remove an object already placed (e.g., remove a spoon from a cup) in order to put a new object into place (e.g., put another spoon in that same cup). Sometimes these children would combine two objects from one class with a single item from the opposite class (e.g., two spoons in one cup), despite the availability of empty recipient items (more cups). For example, one child placed three dolls into separate rings with only minimal intervening activity. After lifting the fourth doll, however, she removed a doll already in a ring and put the fourth doll in instead; two similar substitutions followed. Finally, she put the last doll in a ring with another doll, and left the fourth ring empty (SA, 18 months).

Correspondence construction appeared very different from 24 months on. Object pairs were constructed in immediate sequence: Unused recipient items, and not just any recipient item, were located from the start.

These observations suggest that the first correspondence constructions children produced (at 12 months) were the “artifact” of efforts to reproduce a particular act, possibly for the purpose of reproducing a particular effect. By 18 months, children began to subordinate combinatorial acts to a systematic organization of the objects. The consistency they exhibited in their sequential actions suggests that they were conceptually comparing the objects they contacted. They did something with or to one object, then looked for something else with which or to which to do the same thing, and so on. The organization that the 18-month-olds achieved, however, was limited to one class of objects; that is, to the extension of one term of a two-term relation (actor or recipient). By 24 months, children immediately extended the same relation to pairs of objects (as opposed to one constant object and a variable second object), and in so doing progressively extended two classes.

Trends in the Integration of Relations

If, as we have seen, children from 24 months on extend the same relation to a series of objects, it remains to be seen to what extent they appreciate the equivalence of the separate units they create. Insight into this question may be gained by examining how the subunits of a correspondence are organized into a larger spatial whole.

The first correspondences produced, those at 12 and 18 months, showed no signs of spatial integration. Subjects produced them by maneuvering only one class—for example, placing a doll in each ring or a ring around each doll—and leaving matters at that. Subunits were scattered wherever the receiving objects happened to be.

The first instances of spatial integration of the whole appeared at 24 months. This happened in two ways. With one method children composed the individual subunits of the construction by maneuvering one class, as the 18-month-olds had done. Next, however, they pushed some or all of these pairs together:

**DD, 24 months:** D put a doll in each of the four rings. Next she pushed two pairs together, and then regrouped these next to a third pair.

Half the 24-month-olds used this method. Two of these children used the second method as well. They grouped together items from one class, and then placed items from the second class in one-to-one correspondence with those items:

**ML, 24 months:** M arranged four blocks in a straight line. He put a plate on top of each one.

New variants of each of these methods appeared at 30 and 36 months, when (all) children were also using one or both of the methods used at 24 months. With both variants, the older children interspersed maneuvers carried out only seriatum by the 24-month-olds. The variant of the first method involved drawing some of the subunits in a correspondence together before other subunits were composed:

**NB, 30 months:** N put a doll in each of two boats and then slid these units together. She put a third doll in a third boat, and moved that unit over to the first two. She placed the fourth doll in the fourth boat, and moved that subunit into line as well.

Seven (of 16) 30–36-month-olds used this method. The variant of the second method involved composing individual subunits while drawing single objects, rather than whole subunits, into the array:

**DH, 30 months:** D put a doll in a boat. He drew an empty boat next to the first, and put another doll in it. He put dolls in the remaining boats, and then moved those units into the same line (first method).

Seven children again used this method; five of these children were among the subjects using the other interspersed method.

A probe was administered to elicit the second interspersed method of aligning recipient objects (boats in the above example) while composing the subunits of a correspondence (putting dolls in the boats). Of
particular concern was the question of whether the 24-month-olds could be guided through this procedure, since they were using the component parts of it. The format of the probe was to elicit containment activity and then to present individual objects to the child one at a time in a mixed-class order (to discourage the child from grouping all of one class and then adding the second class to it). The experimenter put out two pairs of objects, uncombined (e.g., a doll next to a ring, and another doll next to another ring some distance away), and asked the child to “fix them up.” Children as young as 18 months spontaneously contained the objects; if this did happen, the experimenter combined them. One unit (e.g., a doll in a ring) was then left on the table while the experimenter proceeded to hand the remaining six objects: doll–ring–r–d–r–d or ring–doll–d–r–d–r. The child was asked to “fix up the rest.” On the first, third, and fifth presentation in either order the child was confronted with a single object for which no counterpart was available (a doll with no ring in which to put it, or a ring with no free doll). At these junctures the child could align the uncomplemented object with the existing subunit(s), thus executing the interspersed procedure. Alternatively, the child could place the object off by itself, combine it with an existing subunit (putting a doll in a ring with another doll), or refuse altogether to place it.

Responses to this probe were remarkably consistent with spontaneous performance. Eleven children (ten between 30 and 36 months, one at 24 months) made perfect correspondences and spatially integrated them in the process, using the prescribed “interspersed” procedure, for example, placing the first ring presented next to the original subunit, putting the next doll in that empty ring, putting the third doll next to the first two subunits, placing the third ring around it (or lifting the doll to put the ring down first), and so on. Most children who used this procedure (N = 7) had used one or both of the interspersed procedures in spontaneous play.

The probe replicated lower levels of performance as well. The 24-month-olds produced perfect one-to-one correspondences, but did not integrate the subunits in the process of doing so. When an object was presented for which no counterpart was available, they either placed that object by itself or refused to place it at all, and gestured instead for another object with which to combine it. The 12- and 18-month-olds confronted with items for which no counterpart existed tended to combine these isolated items with already existing subunits, thus producing imperfect correspondences, such as two dolls in one ring, one doll in another ring, etc.

As in their spontaneous performance, then, the 12–24-month-olds persisted in creating one kind of relation between objects at a time. They persisted in combining (containing) dissimilar objects, even when they were handed the objects in an order that impeded that scheme. The older children, however, easily shifted between two forms of organization: combining dissimilar objects and constructing a larger configuration (by aligning objects next to the other objects like them).

Redefining Object Roles

The 1–2-year-olds’ correspondence construction procedures suggest that these children had difficulty redefining the function of any given object and, in that sense, had difficulty in reclassifying it. This difficulty is particularly evident in the 24-month-olds’ refusal during probing to place into the array an item for which no counterpart existed. These children appear to have evaluated an individual object in terms of whether or not it could be combined with a different object (in the desired format, e.g., containment); if not, no other disposition was considered. By contrast, if the older children found no appropriate counterpart for a given object, they incorporated that same object in some other organization; they put it next to something like it, rather than putting it in or around something not like it.

This trend from role fixity to role flexibility had one further manifestation. The 1–2-year-olds not only persisted in composing the subunits of a correspondence with no interruption, but they composed these subunits in only one way, even when options were available. They put solid objects (e.g., dolls) in rings, or put rings around solid objects (the first method was more usual, although both were observed), but not both. These children never shifted procedures in midstream—for example, put one doll in a ring, then a second ring around a second doll. They resisted such shifts in the elicitation probe, which encouraged a shift. Items in the probe were presented to the child in a scrambled, not an alternating, order—for example, ring–doll–doll–ring–doll–ring. Following this procedure most efficiently, one would place the first ring by itself, put the first doll in that ring, place the next doll on the table, then put the next ring around it. While 18- and 24-month-olds would make the first two moves (putting the ring down and then the doll inside it), they would not make the next two moves (putting the doll down and putting the ring around it). Presented with a doll for which there was no ring, they would refuse to place the doll and reach for a ring instead. If, after considerable coaxing, they released the doll,
they would quickly lift it upon receipt of the next ring; they would place that ring immediately and put the doll inside it.

While the older children also generally avoided reversing the active-passive roles of objects, six of them managed to make at least one reversal in the elicitation probe, and two children spontaneously reversed roles in immediate sequence. An earlier study (Sugarman, 1975) that involved additional probes of role reversibility produced the same pattern of results as the present study.

These findings suggest that the 1–2-year-old children evaluated any given item specifically in terms of whether or not it could be placed in something else (or, for some children, placed around something else); if not, the children made various digressions until such placement was possible. As already suggested by their use of the “interspersed” construction procedures, the older children could redefine object roles. A doll, for example, was something that could be put in something else or was something around which something else could be put. The idea that role reversibility and the “interspersed” construction procedures involve a similar type of coordination is supported by the finding that all children who reverse active-passive roles also used the “interspersed” procedures.

Summary

Children at all ages produced spatial configurations that we may externally describe as involving objects from one class combined in the same format with objects from the second class. But internally, from the subjects’ point of view, the conceptual relations embodied in these constructions seem to have changed.

Correspondence constructions at 1 year appear to have been the largely incidental outcome of efforts to reproduce a particular combinatorial act as an end in itself. Gradually, during the second year, this activity became subordinated to reproducing a particular relation involving some type of functional complementarity. The action sequences involved in composing individual subunits and the analysis of subunit integration converge on this trend. At 12 and 18 months, children's individual-subunit composition strategies did not involve systematic duplication of a relation, and no efforts were made to integrate the subunits once they were produced. The first instances of spatial integration appeared at 24 months, when children were generating identical relations in immediate sequence.

Children began explicitly to intercoordinate these relations at 30 and 36 months. They marked similarities between the subunits of a given correspondence while in the process of constructing them. It may be objected that the 24-month-olds who integrated correspondence subunits after they were all composed (or who grouped one class of objects before composing any subunits) were also marking the similarity of the subunits. However, it is not clear what similarity they were marking. They could have been simply grouping things that look alike, with no simultaneous appreciation that the things that look alike each contains objects related in a particular way. By 30 months children more clearly imposed two types of organization on the array at once.

Common Trends in the Development of Class Grouping and between-Class Correspondences

Presented with small sets of objects divisible into two classes, children between 1 and 3 years of age organize objects by class. They not only put together or successively handle things that are alike (class grouping), but they also construct other regular patterns of similar and dissimilar objects (between-class correspondences). Moreover, they produce the same arrangements. But they go about that production in different ways. Two complementary trends are suggested by the data, each of which highlights the inherent similarity of class grouping and correspondence production at each age.

The Separation of Thought and Action

A gradual disjunction of construction procedure and outcome in producing both class groupings and correspondence suggests a progressive disjunction of action and thought, or, alternatively, increased representational regulation of behavior.

From 1 to 2 years, procedures for constructing class-consistent products mapped directly onto the outcomes they produced. Classes were grouped in space only if they were organized that way first in action, that is, in the order in which the objects were handled. Between-class correspondences were produced simply by repetition of the same act of combination that resulted in a series of identical subunits.

A developmental sequence may be discerned within this period of direct procedure–product mapping. The youngest (12-month-old) subjects showed regularity in their action, but this did not always result immediately in the production of a regular spatial form. Hence, in class
elaborations are successive; that is, one elaboration need not anticipate the next. Examples include: grouping one class and then organizing the other class either by grouping it or by adding it in one-to-one correspondence to the first class; establishing a one-to-one correspondence between dissimilar objects, and then grouping together the identical subunits thus produced.

The fourth phase (30 months on) diverges from the first three insofar as children organize objects according to two schemes at once, rather than only one (or two in succession)—for example, grouping two classes in tandem, spatially organizing one class while organizing the second functionally in one-to-one correspondence to the first, grouping together the subunits of a correspondence while in the process of composing those subunits. In other words, whereas children begin to conceptually interrelate particular objects during the second year, they begin to coordinate relations between objects during the third year.

This account illustrates the clear parallel progress within groups in the construction of class groupings and between-class correspondences. High correlations obtained within individual performance as well. The correlation between subjects’ most advanced (spontaneous or elicited) correspondence construction procedure and their most advanced (spontaneous or elicited) class grouping procedure was .72 (controlling for age, r = .44, p < .01; coefficients for each age group were positive). More specifically, nearly all subjects using coordinated (Phase 4) procedures to generate class groupings also used coordinated procedures to generate correspondences, and vice versa (12 subjects used coordinated procedures for both forms, one subject for correspondences only, and two for class grouping only: corrected χ²(1) = 24.02, p < .001).

The individual and group trends support two major conclusions. One is that substantial changes occur in the kind of conceptual operation in which 1–3-year-olds are engaging when they classify objects in space. The second is that this conceptual evolution can be realized in at least two different spatial patterns: similarity-based groupings of objects and opposition-based “correspondences” in which like objects are separated from one another but placed in functionally equivalent positions.

**Corroborating Evidence**

Data from other studies corroborate one or more of the four phases of conceptual analysis described above.

It was argued that the ordered series of manipulations by the 12-month-olds could have resulted from strategies centered on the indi-
individual object (Phase 1), rather than on relations between objects (Phases 2–4). It is impossible to prove definitively that these children do not take interobject relations into account. Nevertheless, studies of conceptual behavior during the first year thus far give clear evidence of a sequential organization of individual objects (Phase 1), but not a simultaneous comparison of such objects (Phase 2). Infants habituate to series of similar stimuli successively presented to them and recover attention when presented with discrepant stimuli (see Bornstein, in press, for a review). We may infer from these findings, as well as from the anecdotal findings of Piaget (1963) and others, that infants can recognize that something is or is not x. But recognizing individual items as x does not amount to an awareness that several things exist that are the same. Identifying x is not the same as explicitly equating x with some x'. These are concepts of different logical types (see Gopnik, 1980).

Evidence exists outside the present study that children begin to construct equivalence relations between discrete objects during the second year. Forman (this volume) documents the emergence of equivalence relations in block manipulations of a different sort from those considered here. Moreover, his data, like the present findings, suggest that construction of equivalence may first arise in contexts affording abundant perceptual–functional support for such construction. Furthermore, while the present study has documented the emergence of equivalence relations by examining changes in children’s sequential selection patterns, the fact that spatial grouping by similarity becomes readily elicitable during this period is significant by itself. A number of studies report spontaneous or nearly spontaneous spatial grouping of similar objects by the end of the second year (Denney, 1972; Fischer & Roberts, 1979; Nelson, 1973; Ricciuti, 1965); reliable grouping of similar objects seems not to occur during the first year (Langer, 1980). It is also during the second year that children begin to categorize objects verbally, by extending the same name to a series of diverse but related referents (e.g., Clark, 1973; Huttenlocher, 1974; Nelson, Benedict, Gruendel, & Rescorla, 1978). The appearance of relational terms such as “same as” and “like” in children’s language during this period (Donaldson & Wales, 1970; Gopnik, 1980; Sugarman, forthcoming) further supports the emergence of verbal categorization.

The gradual coordination of classes, or interobject relations, during the third year is supported by the appearance of bidimensional classification of simple arrays of objects. Children were presented with sets of objects in which form and color varied independently of one another, thus yielding four subclasses—for example, red and blue dolls, and red and blue rings (Sugarman, forthcoming). During the third year children were able to organize all the objects consistently according to both color and form. For instance, they produced color-coordinated correspondences with red dolls in red rings and blue dolls in blue rings, with same-color units grouped together. These same children could also shift class-grouping criteria when prompted to do so, for example, separating the dolls and rings and then separating the red things and the blue things (see Fischer & Roberts, 1979; Watson & Danielson, 1969; for related findings). Children between 1 and 2 years persisted in grouping according to one criterion, for example, making doll-in-ring correspondences with the color organized haphazardly.

To organize objects along two dimensions, a child must evaluate a given item for its form (e.g., is it a doll or not?) and for its color (e.g., is it red or not?). Broken down in this way, these judgments are analogous to those hypothesized to be entailed in the Phase 4 procedures for grouping two dichotomous classes (or arranging them in one-to-one correspondence). In grouping classes in mixed order, for example, a child judges whether a given item is a doll or not and, if not, whether it is a ring or not. In keeping with this analogy, all subjects who organized objects along two dimensions also grouped dichotomous classes in mixed order or used “interspersed” correspondence construction procedures.

The progressive coordination of relations during the second and third years extends beyond relations of similarity and difference. Children’s procedures for nesting seriated cups follow a progression directly analogous to that observed in correspondence construction. During the second year children nest seriated cups by a method involving perpetuation of only one relation at a time; that is, they continue to look for a cup smaller than or containable within the one before. During the third year they engage in methods involving a functional coordination of inverse relations (smaller-than and larger-than, or containable-in and containable-around). Again analogous to developments in correspondence construction, these third-year methods involve a shift in the functional role of a given cup (from container to contained or from larger-than to smaller-than) (Greenfield et al., 1972; Sugarman, forthcoming).

Early Representational Intelligence Reconsidered

Two views of the nature of early representational intelligence were described at the outset of this chapter. One view, emphasized in most of the larger theories of cognitive development, characterizes early repre-
sentational thought as a direct reflection of sensorimotor intelligence and sees it as undergoing little significant structural change in the year or so after its onset. The second view, derived from studies of language acquisition, is that early representational thought undergoes a certain amount of reorganization within a year or so of its first appearance. The present findings support the latter view.

Changes in children’s cognitive structuring of objects in the second year (Phases 2–3) seem consistent with existing accounts of the onset of representational intelligence. The critical classificatory development in this period is the development of explicit similarity or equivalence relations between individual objects. The construction of these relations requires that children mentally connect two states of affairs while preserving the integrity of each one (knowing that two objects are similar involves knowing they are also discrete). The same requirement exists for the development of symbolic relations between objects or between word and object (McCall et al., 1977; Piaget, 1962, 1963).

The developments observed here during the third year (Phase 4) exceed simple interobject (or interentity) comparisons, since children begin to coordinate, or integrate, such comparisons. The implication of Piaget’s account, however, is that at least until the later preschool years (around age 4) children’s conceptual constructions remain at the level of piecemeal comparisons, or “successive assimilation,” of individual elements, rather than coordination of such comparisons (Piaget, 1977; Piaget, Grize, Szeminska, & Vinh-Bang, 1977; see also Vygotsky, 1962). The strategy of successive assimilation is a direct carryover from sensorimotor intelligence (cf. Inhelder & Piaget, 1964).

The integrative developments of the third year reported here have more in common with characterizations of language development during that period than they do with existing accounts of cognitive development. Children appear to begin the acquisition of various linguistic subsystems with unanalyzed forms, each of which maps directly onto some meaning. During and after the third year these forms are gradually analyzed into subcomponents, and, in the process, are related to other forms (Bowerman, 1973; Karmiloff-Smith, 1979; Newport, 1981). In the process of lexical acquisition, for example, evidence exists that children begin with isolated mapping rules for a few select words in a given domain (e.g., applying one or two color terms to a given set of referents) and then gradually establish a kind of semantic network among related terms (Bartlett, 1977; Bates, 1976; Bowerman, 1978b; Carey, 1978). As with the earlier phases (2 and 3) of children’s conceptual structuring, of arrays in the present investigation, the earlier phase of the language acquisition process (isolated mapping rules) requires the ability to form symbolic relations between things (between words or gestures and some reference world) (e.g., Slobin, 1979). Not long afterward, however, children begin in both areas to intercoordinate these relations.

These parallels by no means reduce language structure to cognitive structure or cognitive structure to language structure. But cognitive processes manifest themselves in language acquisition (Bever, 1970; Karmiloff-Smith, 1979). The cognitive processes that allow children to organize language in new ways ought to allow them to organize other input in new ways.

Why, then, do the integrative advances evident in cognition in the third year appear to have been overlooked by cognitive–developmental researchers? The answer may be, in part, methodological. Piaget and Vygotsky base their accounts of classification on contexts far more complicated than the one used here. Children’s tendencies toward consistent organization may be thwarted under such circumstances (as appears to be the case, for example, in the study of children’s number concepts [e.g., Gelman & Gallistel, 1978]). This is probably not the key methodological source of the discrepancy in findings, however, Piaget’s and Vygotsky’s accounts are based on units that would count as products in the present analysis (see Sugarman, 1979). In the present investigation it was the analysis of process, not of products, that revealed the advances of the third year. In particular, the operations children appeared to be using to produce certain arrays were more complex than those minimally required to generate those arrays. An account based on products alone is thus likely to overlook children’s use of these more complex operations.

Another and perhaps related reason previous accounts seem to have bypassed the present third-year developments concerns theoretical emphasis. Even when looking at behavior directly suggestive of the kinds of conceptual coordinations described here, Piaget seems to have been preoccupied with other aspects of that behavior. Piaget (1962, Part III) tentatively describes verbal arguments children begin to make in the third year as the beginning of reasoning. Reasoning, by his account, is signaled by a coordination of judgments:

It is very difficult to agree as to the earliest examples of reasoning. Coordination of judgments passed with regard to the same situation, each of these judgments corresponding merely to a perceptive reading of it, cannot be called reasoning. Reasoning...
must involve judgments going beyond the field of immediate perception and connected with it by a bond of necessary subordination [Piaget, 1962, p. 230, Note 1].

Initially, however, the coordination of judgments is usually lacking in "necessary subordination." In a commonly cited example (Obs. 111), Piaget's daughter, J, is told she cannot have oranges because they are still green, that is, not ripe; if the oranges were ripe they would be yellow. Later, while drinking camomile tea, which is yellow, J asserts, "Camomile isn't green. It's yellow already... Give me some oranges! [p. 231]." J goes beyond a "perceptive reading" of the tea and oranges, and "infers" that the oranges must be yellow (and therefore edible). In discussing this and other examples, Piaget stresses the assimilative quality of the child's remarks: The child egocentrically assimilates oranges to tea, and does not acknowledge the possibility that despite certain similarities (tea has the color of ripe oranges), critical differences may exist.

But the fact remains that a coordination of judgments is required to draw the analogy between the oranges and the tea in the first place. While the child does not normally class together oranges and tea, she does so for the present purpose, however pragmatic and lacking in necessary subordination (class inclusion) that purpose may be.

On several occasions the strategies used by the 2½- and 3-year-olds in the present study were claimed to involve a coordination of judgments. This claim was made because the children considered alternative ways in which a given object could be related to other objects. For example, it was argued that children who shifted between classes while grouping them immediately "reclassified" an item judged not to belong to one class as an item belonging to another class; they did not reject the item out of hand. In the production of correspondences, an item judged to have no functional counterpart could, alternatively, be grouped with the existing array, which included other items like it. Furthermore, a given item (e.g., a doll) could be incorporated in either of two combinatorial schemes (being placed in a ring or having a ring placed around it) in order to yield the same spatial relation (a doll contained in a ring).

The appearance of these strategies can be seen as the beginning of reasoning in a nonverbal context. This characterization does not preclude the possibility of severe limitations on early reasoning. It remains to establish, for example, to what extent these simple conceptual coordinations can occur independently of a pragmatic context (such as organizing objects in space) or without the radically assimilative reduction of one event to another described by Piaget (as in the oranges and tea example).

Nevertheless, however limited it may be, early reasoning in nonverbal or formal form represents an advance over initial representational intelligence. It involves more than representing or symbolizing something and more than conceptually relating one thing to another particular thing. It involves a coordination or deeper analysis of these relations.

Children take an equally large step in this period in language development. After they begin to encode very simple propositions in language (e.g., Brown's [1973] Stage I), they begin to codify the linguistic system itself. They organize semantic fields and develop a grammar. It makes sense that the dawn of reasoning should coincide with the dawn of language proper, although the two do not amount to the same thing. Each one is a significant advance toward human rationality.

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