Young Children's Understanding of Attributes and Dimensions: A Comparison of Conceptual and Linguistic Measures

Linda B. Smith
Indiana University

SMITH, LINDA B. *Young Children's Understanding of Attributes and Dimensions: A Comparison of Conceptual and Linguistic Measures.* CHILD DEVELOPMENT, 1984, **55**, 363–380. Preschoolers' (2-, 3-, and 4-year-olds) understanding of attributes and dimensions was examined in 3 experiments. Attribute knowledge is the knowledge that a particular attribute—for example, red—can be instantiated in a variety of distinct objects. Dimension knowledge is the knowledge that there are qualitatively distinct kinds of attributes; for example, red and blue are attributes of the same kind, a kind that is different from that of big. Preschoolers' understanding of attributes and dimensions was assessed by both a conceptual measure and a linguistic measure. A language-free follow-the-leader task served as the conceptual measure. In this task, all the children showed strong attribute knowledge. However, 2-year-olds did not appear to differentiate attributes into their dimensional kinds. The observed trend in the linguistic task was not isomorphic to that observed in the conceptual task. The acquisition of some attribute and dimension labels appears to follow closely the trend in conceptual development, whereas the acquisition of others (specifically, size-attribute labels) lags severely behind the attainment of the basic concepts. The results provide new information about the development of object comparison and the acquisition of dimensional terms.

The notion of dimensions is crucial to much thinking about how humans compare objects. Often when we compare one object to another, we seem to do so in terms of distinct aspects of difference such as color, size, and shape. However, much evidence suggests that young children do not compare objects dimensionally. For example, in classification tasks, older children consistently assign objects into groups by value on a single dimension, but children under age 5 do not (e.g., Bruner, Olver, & Greenfield, 1966; Inhelder & Piaget, 1964; Vygotsky, 1962). Instead, preschool children consistently classify objects by their wholistic similarity across many dimensions (Kemler, 1983; Shepp, Burns, & McDonough, 1980; Smith, 1979; Smith & Kemler, 1977). Findings in discrimination-learning tasks also suggest that dimensions play a limited role in young children's comparisons of objects. In such tasks, older children learn rules about component attributes and dimensions. Preschool children, however, tend to learn rules about whole objects and not component attributes (Kendler, 1979; Tighe & Tighe, 1972; Zeaman & House, 1974). There appears, then, to be a developmental trend from the undifferentiated comparison of whole objects to the comparison of objects in terms of attributes on separate dimensions.

How one should interpret this well-documented developmental trend is far from clear. On the one hand, the young child's nonuse of dimensions on such tasks may reflect the lack of a basic ability to represent objects in terms of their dimensional components. On the other hand, the young child may represent objects dimensionally but for some reason fail to use this information

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when comparing objects. As several investigators have pointed out (Kemler, 1982; Kendler, 1979; Tighe & Tighe, 1978), the evidence from object-comparison tasks is difficult to assess because the age differences are not of an all-or-nothing kind. Dimensional analysis tasks such as classification and discrimination learning are clearly hard for young children. However, young children do attend to separate dimensional relations under certain task procedures (e.g., Caron, 1969; Kemler, 1983; Odom, 1978; Smith, 1979; Tighe & Tighe, 1966). The developmental trend, then, is from lesser to greater use of dimensions, and the question is whether the developmental increase in use reflects changes in the representation of dimensional relations or changes in other abilities perhaps crucial to the use of that information. Pertinent to this issue is the fact that tasks such as classification and discrimination learning are quite complex and require many skills for success, not the least of which may be an understanding of the task itself.

The purpose of the present research is to provide new information about the development of dimensional comparison. This is done by rephrasing the empirical question. Instead of asking how well the child uses dimensions in some cognitive task, this research asks what the nature is of the child's knowledge about dimensions. The assumption that underlies this shift in focus is that dimensional comparison is not a unitary ability but one that includes an understanding of relations. One potential component of an understanding of relations is the knowledge that a particular attribute—for example, red—can be instantiated in a variety of distinct objects. Dimensional comparisons require that objects that are equivalent in their possession of a particular attribute be represented as equivalent. A second distinct component of relational knowledge concerns dimensions. This component involves the knowledge that there are qualitatively distinct kinds of attributes. Put another way, it is the knowledge that a particular dimension exists. For example, red and blue are attributes of the same kind, a kind that is different from that of big. The mental organization of attributes into qualitative kinds is the crux of the notion of a psychological dimension. The knowledge that red and blue are attributes of a particular kind is the knowledge that there is a color dimension. This distinction between an understanding of attributes and an understanding of dimensions has not been specifically made in standard studies of object comparison (see Kemler, 1983, for a discussion of this point). However, the determination of when children understand these two aspects of dimensional comparison would seem critical to explanations of the developmental trend in object comparison.

The distinction between attribute and dimension knowledge has been made in hypotheses about children's acquisitions of dimension words. Two specific hypotheses about language suggest that attribute and dimension information are developmentally separate components of dimension-word meanings. E. Clark (1973) suggested that in acquiring dimension words, the preschool child first sorts out the dimensions—for example, differentiates size words (e.g., "big" and "little") from space words (e.g., "high" and "low"). Later the child is said to figure out which attribute words label which specific attributes. In contrast, Carey (1978) suggested that in learning dimensional words, the child sorts out or differentiates dimensions last. The child is said to have some understanding of attribute labels before attribute labels are linked to qualitatively distinct dimensions. Thus, for example, a child might apply the word "big" to both big and bright objects. Both hypotheses about linguistic development suggest that attributes and dimensions are separate aspects of the relational knowledge system; the hypotheses differ in the postulated order of acquisition of attribute and dimension knowledge. Which of the two hypotheses is most correct about linguistic development need not be the one that is most correct in the conceptual domain. The developmental trend in language acquisition may not reflect perfectly the growth of underlying concepts. As Slobin (1973) points out, linguistic acquisitions may be constrained by either cognitive or specifically linguistic factors. One way to assess whether linguistic development reflects conceptual or specifically linguistic growth is to directly compare conceptual and linguistic development.

In summary, children's understanding of attributes and dimensions may illuminate developmental trends in object comparison. Further, an investigation of children's concepts in this domain may provide information useful to accounts of how children come to linguistically refer to relations between objects. Accordingly, the primary focus of the empirical studies reported here is on the development of an understanding of attribute and dimensional relations. The studies also include a direct comparison of conceptual and linguistic development.

A necessary secondary focus of this research is methodological. The design of a task to measure children's conceptual knowledge of attributes and dimensions presents considerable problems. Children's conceptual knowledge is often inferred from their ability to answer questions verbally. Such a method is not suitable to the present goal of comparing conceptual and linguistic development. An experimental task was needed that was virtually language free and thus a potential measure of conceptual knowledge independent of linguistic development. However, success in the task must require conceptual knowledge and not, perhaps, just the perceptual abilities on which such knowledge may be built. In other words, a task was desired in which the mental representation of attributes and dimensions was prerequisite for success. Finally, the behaviors required of the child to perform the task needed to be transparent to the child to conclude from a failure that the child lacked the critical concepts rather than an understanding of the measuring task itself. The task employed in Experiment 1 was designed to measure children's conceptual understanding of attributes and dimensions, and the task meets the critical requirements.

Experiment 1

Through several pilot studies, a follow-the-leader task was developed. The logic behind the task is as follows: If a young child imitates an experimenter's choice of objects from some set and preserves in his or her own object choices the attribute or dimension that governed the experimenter's choice, then the child must mentally represent either attributes or dimensions or both. This reasoning is best clarified by considering the experimental procedure and examples of actual trials.

On all trials, there were three participants—two experimenters and the child. A set of nine objects was distrubuted to the participants such that each participant had three objects. The first experimenter made a selection from her set, then the second experimenter made a selection from her set. The child was instructed to follow the experimenter's lead and select objects from his or her set. Five major types of stimulus trials were designed to measure the child's understanding of attributes, dimensions, and several abilities that might be crucial for success in this task. Examples of the five trial types are given in Table 1.

Consider first the Attribute 1 trials, the trials designed to measure the child's knowledge that distinct objects may be conceptualized as equivalent if they possess an identical attribute. In the example in Table 1, the first experimenter would take the red large flower, saying simply, "I take this one." The second experimenter would then take the red small flower, saying "I take this one." A child would demonstrate attribute knowledge if he or she chose the red medium-sized flower. Such a correct choice implies the mental representation of the shared attribute. From the two experimenters' demonstrations, the child must infer a rule about object choice. A correct choice must be based on reasoning something like the following: "E_1 chose the big red one and E_2 chose the little red one. These two objects are alike in that they are red, so I should choose a red one." Each child received in random order both trials on which a choice by a color attribute was correct and trials on which a choice by a size attribute was correct. Thus, to succeed, the child must attend to and mentally relate both experimenters' choices. If the child attended to only one experimenter's choice, he or she would have no basis by which to decide whether to match the attended experimenter's choice in color or size.

The Attribute 2 trials were also designed to measure the child's understanding of attribute relations. These trials differed from the Attribute 1 trials in that each participant was to choose two objects, as shown in Table 1. The Attribute 2 trials were included for two reasons. First, the critical attribute is clearly demonstrated by just one experimenter's choice. Therefore, a child could succeed on these trials if he or she were able to detect and infer rules about shared attributes but was unable to coordinate the choices of two separate individuals. Second, the trials designed to tap the dimension concept required each participant to choose two objects. The Attribute 2 trials thus provide a measure of any extra difficulties the children might have on the Dimension trials that were due simply to the number of objects to be chosen.

An example of a Dimension trial is shown in the third column of Table 1. These trials were designed to measure the child's knowledge that attributes are of qualitatively

TABLE 1

EXAMPLES OF FIVE TRIAL TYPES IN EXPERIMENT 1

PARTICIPANT	Trial Type: Attribute 1	Attribute 2	Dimension	Identity	Identity-Analogy
E_1	*Red, 5″ flower*	*Red, 5″ block*	*Red, 3″ house*	*Green plane* (lg.)	*Red car (lg.)*
	Yellow, 3″ flower	*Red, 1″ block*	*Red, 5″ house*	Red apple (sm.)	*Red car (lg.)*
	Blue, 1″ flower	Yellow, 1″ block	Blue, 5″ house	Yellow pig (med.)	Blue cow (med.)
E_2	*Red, 1″ flower*	*Red, 1″ block*	*Yellow, 5″ house*	*Green plane* (lg.)	*White daisy (med.)*
	Yellow, 5″ flower	*Red, 3″ block*	*Yellow, 1″ house*	Blue boy (sm.)	*White daisy (med.)*
	Blue, 3″ flower	Yellow, 5″ block	Red, 1″ house	White ball (med.)	Pink chair (sm.)
Child	Red, 3″ flower	Red, 3″ block	Blue, 1″ house	Green plane (lg.)	Green cup (sm.)
	Yellow, 1″ flower	Red, 5″ block	Blue, 3″ house	Orange pumpkin (sm.)	Green cup (sm.)
	Blue, 5″ flower	Yellow, 5″ block	Yellow, 3″ house	Purple goose (med.)	Yellow banana (lg.)

NOTE.—Objects selected by experimenters are indicated by italics.

different kinds. To illustrate, in the example in Table 1, the first experimenter would take two red but different-sized objects from her set, saying "I take these two." The second experimenter would then take two yellow but different-sized objects from her set. Knowledge of the relevant dimension—color—would be indicated by the child's choice of the two blue objects from his or her set. Again, a correct choice requires the child to infer a rule from the experimenters' choices; in this case, the rule to be inferred is the dimensional one of sameness in color. Notice that a correct choice requires the differentiation of dimensions. If, in the example, the child did not differentiate sameness in color from other kinds of sameness, he or she might choose the two objects that are the same size rather than the same color. Notice, also, that a correct choice is based on the identity of a relation and not on any concrete physical identity. In other words, the child is asked to make an analogy, in the example, red is to red as yellow is to yellow as —— is to ——.

Two additional types of trials were also included in the task, and examples are given in the last two columns of Table 1. The purpose of these trials was to foster the child's understanding of the task and to provide a measure of that understanding independent of attribute and dimension knowledge. On the Identity trials, the two experimenters chose objects that were identical to each other in all respects. The child's set contained an identical replication of the experimenters' choices and did not contain any other objects that were similar in any way to the objects chosen by the experimenters. If a child understands the follow-the-leader task at all, he or she should succeed on these trials.

The purpose of the Identity-Analogy trials, shown in the last column of Table 1, was to determine whether any difficulties the child might have on the Dimension trials was specific to an understanding of dimensions rather than a general inability to infer rules about abstract relations. As in the Dimension trials, the correct choice of a pair of objects requires the child to make an analogy. No concrete property or combinations of properties is sufficient for specification of the objects to be selected. Rather, to succeed, the child must realize, for example, that two large red cars are alike in the same way as two smaller white daisies and as two very small green cups. The abstract relation of relevance is total identity. One could argue that the Identity-Analogy trials do not provide a good measure of the child's ability to infer a nondimensional rule about an abstract relation. Total identity could be such a salient relation that even without any demonstration by the experimenters, young children might spontaneously select two identical objects from a set of three. This possibility was assessed by testing a separate group of children in a No-Demonstration version of the Identity-Analogy trials.

In summary, young children's knowledge about attributes and dimensions was assessed by asking children to infer object-choice rules about attributes and dimensions in a follow-the-leader task. Two supplementary abilities were also measured: the ability to infer an object-choice rule not based on component attributes, and the ability to make a nondimensional analogy.

Method

Subjects.—Thirty children attending day-care centers serving a middle-class population participated. The mean age and range of ages for the 10 children at each of three age levels were as follows: (1) 2-year-olds (*M*, 2-6; range, 2-3 to 2-10); (2) 3-year-olds (*M*, 3-5; range, 3-2 to 3-9); and (3) 4-year-olds (*M*, 4-6; range, 4-1 to 4-9). In addition, 18 2-year-olds (*M*, 2-4) served as subjects in the No-Demonstration task.

Stimuli and Design

A total of 252 stimulus objects arranged into 28 supersets of nine, subdivided into three sets of three objects each, were employed. The nine stimuli comprising each of the 28 trials were unique from the stimuli used on other trials. Thus, a child never had to choose a particular object on one trial and reject that object on another trial in order to be correct. The stimulus objects consisted of small toys, either purchased or constructed, of a variety of types, including dishes, furniture, animals, towers, houses, flowers, food, and blocks. The supersets of nine objects were structured in various ways to conform to the five major trial types: (*a*) Attribute 1; (*b*) Attribute 2; (*c*) Dimension; (*d*) Identity; and (*e*) Identity-Analogy.

There were four Identity trials and four Identity-Analogy trials. The objects utilized in these trials varied in color, size, and overall shape and were structured as shown in Table 1.

There were eight Attribute 1 trials. On four of these trials, the nine stimulus objects varied only in color and size (specifically, in vertical size or tallness). On the remaining four Attribute 1 trials, the stimulus objects varied in color and overall shape or in size and overall shape. The nine objects used for one trial resulted from all possible combinations of three values on each varying dimension and were subdivided into three sets of three such that the objects in each set of three instantiated each of the three attributes on the two varying dimensions (see Table 1). On four of the Attribute 1 trials, color was relevant; the particular color attribute (red, blue, green, or yellow) that governed the experimenters' choices was unique to a particular Attribute 1 trial. On the remaining four Attribute 1 trials, size was relevant and the particular size attribute (12, 9, 3, or 1 in) that governed the experimenters' choices was unique to a particular trial. However, on two of these trials, the relevant size attribute was the tallest object in set, and on two of the trials the relevant size attribute was the shortest object in the set.

There were four Attribute 2 trials. On all four trials, the objects varied in only color and size. On the two trials in which color was relevant, the nine objects were composed of two color attributes and three size attributes. On the two trials in which size was relevant, the nine objects were composed of two size attributes and three color attributes. Within each set of three objects to be operated on by one participant, two objects possessed the attribute governing choice and differed on the irrelevant dimension and two objects shared a value on the irrelevant dimension but differed on the relevant dimension (see Table 1). The particular attributes governing object choice were unique to each trial as in the Attribute 1 trials.

There were eight Dimension trials. On half of these trials, the objects varied only in color and size (tallness), and on the other half only in color and overall shape or in size and overall shape. On half the trials color was the relevant dimension and on half size was relevant. The nine objects utilized on a trial were composed of three values on each of the two varying dimensions. Within each set of three objects to be operated on by a participant, two objects were identical on the relevant dimension and differed on the irrelevant dimension, and two objects were identical on the irrelevant dimension and differed on the relevant dimension. The particular attributes on both the relevant and irrelevant dimension that were repeated in a set of three were unique to that set of three within a trial (see Table 1).

In total, there were 12 Choose-One trials (four Identity and eight Attribute 1 trials), trials on which each participant was to choose one object. These 12 trials were arranged in two random orders for presentation. The 16 Choose-Two trials, on which each participant was to choose two objects (four Identity-Analogy, four Attribute 2, and eight Dimension trials), were arranged in two random orders for presentation. Half the children at each age level received the 12 Choose-One trials before the 16 Choose-Two trials, and half received these trials in the inverse order.

Procedure.—Each child was tested individually in two to four sessions that lasted from 10 to 20 min. At the beginning of the first session, the child was asked if he or she knew how to play follow the leader. The three participants then briefly played follow the leader using acts such as hands put on head or over eyes. The child was then told that the three participants were going to play follow the leader with some toys. The first sets of toys were then distributed to each participant. The toys within each participant's set were haphazardly arranged. The first experimenter would then select a toy or toys from her set, saying only "I take this one" on Choose-One trials and "I take these two" on Choose-Two trials. The chosen object or objects would then be set in the middle of the table around which the three participants sat. The second experimenter would then make her choice in a manner identical to the first experimenter. On Choose-One trials, the second experimenter placed her chosen object close to the first experimenter's choice. On Choose-Two trials, the second experimenter placed her two choices close together and spatially separated from the first experimenter's choices. The child was then asked to "do what we did, take one [or two] of your toys and put them here" with a motion to the center of the table. If necessary, the child was further encouraged to take an object or objects, but no feedback was given. After the child's choice the objects were removed, and the objects for the next trial were distributed. Subsequent sessions began with a "reminder" of how to play follow the leader and proceeded in a manner identical to that of the first session.

For the No-Demonstration task, a separate group of 18 children were given the child's sets for the Identity-Analogy trials. Half the children were given no instructions and were just observed playing with the objects. Half were given the objects and asked to take two. The first two objects touched in succession by a child under either version of instructions were scored.

Results and Discussion

Identity and Identity-Analogy trials. —Each child was scored as passing the Identity and Identity-Analogy trials if he or she chose the correct object(s) on at least three of the four trials of each type. The probability that a child could pass one of these trial types by chance alone is .108. All the children at each age level passed the Identity trials. The probability that 10 of 10 children passed these trials by chance alone is less than .0001. Apparently, all the children understood the task and were able to choose an object that was identical in all respects to the objects chosen by the experimenters. All but one child (a 2-year-old) passed the Identity-Analogy trials. The probability that nine of 10 children passed these trials by chance alone is less than .0001. This level of performance suggests the children were able to make an analogy and to imitate object choices by at least one abstract relation—that of total identity. A comparison of the performance of the 18 2-year-olds in the No-Demonstration version of the Identity-Analogy trials with that of the 10 2-year-olds in the main experiment bolsters this suggestion. For this comparison, the scores of all 28 children were based on the first two objects touched in succession. Under the follow-the-leader procedure, the 2-year-olds chose in this manner two identical objects on 88% of the trials. In contrast, in both versions of the No-Demonstration task, the children spontaneously chose the two identical objects on less than 50% of the trials. Thus, it appears that the 2-year-olds in the main experiment were inferring a rule from the experimenters' choices. If E_1 took two identical cups and E_2 took two identical balls, the child correctly derived the rule and chose two objects that were identical to each other but different from the objects chosen by the experimenters.

These results on the Identity-Analogy trials are important for two reasons. First, the results show that even very young children are able to make analogies and infer abstract rules. In this regard, and in contrast to other theorists' views (e.g., Inhelder & Piaget, 1964), 2-year-olds are able to represent and mentally manipulate more than static, concrete properties of objects (see Sugarman, 1982, for a similar conclusion). Second, the overwhelming success of the children on the Identity and Identity-Analogy trials indicates that the follow-the-leader task was understood by the children. Any difficulties on the children's part on the Attribute and Dimension trials, then, would seem to be difficulties specific to the child's concepts of attributes and dimensions and not general task difficulties.

Attribute and Dimension trials.—A number of preliminary analyses were conducted. The purpose of these analyses was to determine whether performance depended on specific instantiations of Attribute and Dimension trials. Item analyses were performed separately for each of the following four sets of trial types: (1) Attribute (1 and 2 inclusive)—color relevant; (2) Attribute (1 and 2 inclusive)—size relevant; (3) Dimension—color relevant; and (4) Dimension—size relevant. Reliable differences between performances on specific items within a type did not emerge. Across the three age levels, then, performance does not appear to depend on the specific instances of a trial type, and thus neither on the specific irrelevant dimension nor on the number of objects to be chosen on the Attribute trials. The potential effect of the irrelevant dimension—shape, a dimension by which object choice was never governed versus color or size, the two dimensions that were each relevant on half the trials—was also examined separately for the Attribute and Dimension trials with scores collapsed across the relevant dimension. At no age level and for neither the Attribute nor the Dimension trials did performance depend on whether the irrelevant dimension was sometimes relevant for object choice, $t(9) < 1.20$, $p > .10$, in all six cases. At each age level, children also appeared to perform equally well on both Attribute 1 and Attribute 2 trials. All children who passed (75% correct) one type of attribute trial also passed the other (except one 3-year-old who performed at a 50% correct level on the Attribute 2 trials). The final set of preliminary analyses compared performance on trials in which color was relevant and on trials in which size was relevant. Children at all age levels and on both Attribute and Dimension trials tended to perform better on the size- than the color-relevant trials. However, this trend was not reliable by parametric tests conducted separately for each age level with scores collapsed across Attribute and Dimension trials nor by nonparametric tests conducted separately for the two major trial types across the three age levels (see Table 2).

In light of these preliminary analyses, the children's proportion of correct choices was submitted to an analysis of variance for a 3(age) × 2(trial type) mixed design. The analysis yielded main effects of age, $F(2,27) = 13.53$, $p < .001$, and trial type, $F(1,27) = 110.85$, $p < .001$, and a reliable interaction between the two factors, $F(2,27) = 42.52$, $p < .001$. As is evident in Table 2, children at every age were quite able to follow the experimenters' leads in choosing objects by a particular attribute. The 2-year-olds performed significantly less well (Tukey's $\alpha = .05$) on the Attribute trials than the 3- and 4-year-olds, but their mean level of performance (76% correct) was, nonetheless, quite high. Eight 2-year-olds, nine 3-year-olds, and all 10 4-year-olds performed at or above a level of 75% correct on the Attribute trials. As shown in Table 2, marked developmental differences did emerge in performance on the Dimension trials—the trials on which children, to be correct, were required to imitate choices by the kind of dimensional relation rather than by a particular attribute. On these trials, 2-year-olds performed significantly less well than the 3-year-olds, who in turn performed significantly less well than the 4-year-olds (Tukey's $\alpha = .05$). If 75% correct is deemed as passing, *no* 2-year-old exhibited passing-level performance, whereas seven 3-year-olds and all 10 4-year-olds did. These results suggest that an understanding of attributes, or, more specifically, the ability to represent the equivalence of objects in terms of component attributes and to infer rules about attributes, develops quite early, certainly by 2 years of age. An understanding of dimensions appears to develop slightly later, beginning to be evident in many 3-year-olds but not evident at all in 2-year-olds.

The claim that 2-year-olds do not understand dimensions and do not represent attributes as instances of qualitatively distinct dimensions is supported by the kinds of errors 2-year-olds made on the Dimension trials. On each Dimension trial, the child could select three possible pairs of objects (see Table 1): (1) a correctly related pair of objects—the two objects that were identical on the same dimension as the objects in the pairs chosen by the experimenters; (2) an incorrectly related pair—the two objects that were identical on the irrelevant dimension; and (3) an unrelated pair—the two objects that differed on both the relevant and irrelevant dimension. Two-year-olds chose the correctly related pair on 45% of the trials and the incorrectly related pair on 40% of the trials. On the Dimension trials, then, 2-year-olds primarily chose objects that were alike in some way, but they did not differentiate *kinds* of alikeness, and thus chose objects related in a different way from the experimenters' as often as they chose objects related in the same way, $t(9) < 1.00$. As attested to by their performance on the Identity-Analogy trials, the 2-year-olds understood the basic nature of the follow-the-leader task and apparently were inferring object-choice rules from the experimenters' demonstrations. These young children inferred rules about concrete attributes and about the abstract relations of total identity and undifferentiated similarity, but they did not infer rules about dimensions.

In conclusion, the results of this experiment suggest, first, that young children possess a good understanding of attributes and dimensions, but that very early in development dimensions are not differentiated. This developmental pattern clearly shows that attributes and dimensions are distinct aspects of a general understanding of object relations. Second, the children's performances indicate several well-developed cognitive skills. There were vir-

TABLE 2

Number of Children (of Ten) Achieving at Least 75% Correct and the Mean Proportion Correct for All Children at Each Age Level on the Attribute and Dimension Trials of Experiment 1

	Trial Type											
	Attribute						Dimension					
	Color		Size		Total		Color		Size		Total	
Age (Years)	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$	N	$\bar{X}$
2	7	.71	8	.80	8	.76	0	.39	0	.49	0	.45
3	9	.80	10	.90	9	.85	7	.68	8	.80	7	.74
4	10	.85	10	.95	10	.90	10	.86	10	.92	10	.89

tually no instructions in the experimental task. The children had to infer rules about object choices and make analogies—considerable cognitive feats in their own right. All the children, including 2-year-olds, were well able to infer rules and to make analogies.

Experiment 2

In the first experiment, directed to children's conceptual knowledge of attributes and dimensions, attribute relations were found to be developmentally prior. The primary question behind this second experiment was whether such conceptual knowledge was related directly to children's linguistic knowledge. In other words, is an understanding of the words that label attributes prior to an understanding of the words that label dimensions?

Method

Subjects.—The subjects were 10 2-year-olds (*M*, 2-7; range, 2-3 to 2-10); 10 3-year-olds (*M*, 3-5; range, 3-2 to 3-10); and 10 4-year-olds (*M*, 4-7; range, 4-3 to 4-10) from the same day-cares as the children who participated in Experiment 1.

Stimuli.—The stimuli consisted of the child's sets used for the Attribute 1, Attribute 2, and Dimension trials of Experiment 1. As in Experiment 1, the sets were arranged into two blocks, those requiring the choice of one object and those requiring the choice of two objects. The randomization of trials and the counterbalancing of blocks were identical to that in Experiment 1.

Procedure.—At the beginning of the first session, the child was asked if he or she knew how to play "Simon-says." Several warm-up trials then ensued (e.g., "Simon-says put your hands on your head"). The child was then told that he or she was going to play Simon-says with some toys. The first set of three toys was then given to the child and the experimenter gave the appropriate instruction. On Attribute 1 trials, the child was told "Simon-says take the red [blue/green/yellow] one" (one trial for each unique color term) or "Simon-says take the tall [short] one" (two trials for each size term). On Attribute 2 trials, the child was told "Simon-says take the two red [green/tall/short] ones" (one trial each term). On the Dimension trials, the child was told "Simon-says take two that are the same color [size]" (four trials, each term). If a child did not respond to the instruction, it was repeated and then rephrased (e.g., "Which one is tall?" or "Which two are the same size?"). The children were tested individually in two to three 10–20-min sessions.

Results and Discussion

Preliminary analyses indicated that performances on the Attribute 1 and Attribute 2 trials did not differ. However, marked asymmetries in performance as a function of the relevant dimension did emerge and are apparent in Table 3, both in terms of the numbers of children passing particular trial types (achieving at least 75% correct) and the mean proportions of correct object choices. Overall, the 2-year-olds performed poorly and showed little comprehension of attribute and dimension terms, although four of the 2-year-olds did know the referents of color-attribute terms. In contrast, many of the 3-year-olds and all of the 4-year-olds understood color-attribute terms and the dimension terms of size and color. The 3- and 4-year-olds performed poorly only on the size-attribute trials. Across trials, when asked to choose the tall or short object(s), 3- and 4-year-olds clearly failed to understand the instruction.

TABLE 3

NUMBER OF CHILDREN (of Ten) ACHIEVING AT LEAST 75% CORRECT AND MEAN PROPORTION CORRECT FOR ALL CHILDREN ON COLOR- AND SIZE-RELEVANT ATTRIBUTE TRIALS AND DIMENSION TRIALS IN EXPERIMENT 2

	TRIAL TYPE							
	Attribute				Dimension			
	Color		Size		Color		Size	
AGE (Years)	*N*	$\bar{X}$	*N*	$\bar{X}$	*N*	$\bar{X}$	*N*	$\bar{X}$
2.............	4	.63	1	.48	0	.37	0	.45
3.............	9	.75	1	.53	6	.60	7	.68
4.............	10	.98	2	.58	10	.92	10	1.00

The patterns of performances leading to the children's failures on the linguistic task with size-attribute terms were quite systematic. As shown in Table 4, at all age levels, the children chose the tall object when asked to do so reliably more often than expected by chance, but at no age level did the children reliably choose the short object when asked to do so. This asymmetry in the comprehension of the terms labeling the attributes of ordinal dimensions has been reported often in the language-acquisition literature (e.g., Bartlett, 1976; Donaldson & Wales, 1970). In contrast to certain hypotheses about the acquisition of dimensional words (E. Clark, 1973) but consistent with other findings in this area (e.g., Weimer, 1974), the object choices in response to the label "short" do not indicate a systematic misinterpretation of "short" as meaning tall. Two- and 3-year-olds' object choices when asked to take the short one do not differ from the distribution expected by chance, $\chi^2(2) = .708$ and 1.91 for 2-year-olds and 3-year-olds, respectively, and 4-year-olds consistently do not choose the tallest object when asked to get the short one but rather divide their choices quite evenly between the medium-sized and the short object.

The pattern of errors on the Dimensions trials also is informative. Two-year-olds haphazardly chose a pair of objects when asked to take two the "same color" or the "same size." They distributed their choices equally often, $\chi^2(2) = 2.01$, between the three possibilities—(1) objects the same on the relevant dimension, (2) objects the same on the irrelevant dimension, and (3) objects that were not the same on either dimension. The 2-year-olds' errors, then, do not stem from the interpretation of "same color" or "same size" as meaning the same in some way. Rather the 2-year-olds do not appear to understand the verbal requests at all. This pattern of performance contrasts with that of the 2-year-olds in Experiment 1. Whereas 2-year-olds appear not to understand the verbal instructions, they do understand the follow-the-leader task, as evidenced by their choice of objects related in some way on the Dimension trials of Experiment 1. Three-year-olds' errors with "same color" and "same size" were primarily choices of objects related on the irrelevant dimension; 32% of all choices by the 3-year-olds on the Dimensions trials consisted of choosing the two objects that were alike on the irrelevant dimension.

TABLE 4

PROPORTIONS OF OBJECTS CHOSEN IN EXPERIMENT 2 IN RESPONSE TO INSTRUCTIONS TO TAKE THE "TALL" ONE OR "SHORT" ONE (Attribute 1 Trials)

Age (Years) and Object Chosen	Label: Tall	Label: Short
2:		
Tall	*.55**	.35
Medium	.30	.40
Short	.15	*.25*
3:		
Tall	*.70**	.45
Medium	.25	.20
Short	.05	*.35*
4:		
Tall	*.65**	.07
Medium	.25	.43
Short	.10	*.50*

NOTE.—Proportions of correct choices for each label are given in italics.

* Correct choices significantly greater than expected by chance, $\chi^2(1)$, $p < .05$.

The results of this experiment suggest that the developmental ordering of attribute and dimensional knowledge is not retained perfectly in linguistic development. The comprehension of the linguistic labels for color attributes and the distinct dimensions of color and size appears to follow closely the attainment of the basic concepts. The comprehension of the two linguistic labels for size attributes, however, is delayed. The lag is so great that the order of conceptual growth—attributes before dimension—is reversed in linguistic development for the size dimension. By the follow-the-leader measure, children understand size attributes before they organize these attributes into one dimension, but by the linguistic measure, children understand the verbal label for the dimension before they fully comprehend the labels for two specific size attributes. This result highlights the fact that the order of linguistic acquisitions need not reflect the order of acquisition of the underlying concepts.

The contrast between conceptual abilities as indexed by nonverbal and verbal measures is also evident in some pilot data. Eight 2- and 3-year-olds (who did not take part in the main experiments) participated in two versions of the follow-the-leader task. One version of the task was identical to that employed in Experiment 1. Two experimenters chose object(s) from their sets and did not use any dimensional terms when talking about their choices, saying only "I take this one" or "I take these two." The second version was identical to the first except that both experimenters used attribute and dimension labels in talking about their choices, saying, for example, "I take the red one" or "I take two the same color." One might expect performance in the Demonstration and Demonstration-plus-label versions to be equivalent, or that performance in the Demonstration-plus-label version would be superior. After all, in the Demonstration-plus-label task, the child has two routes to success—inferring an object-choice rule from the demonstrations and comprehending the words that state the rule. However, the children actually performed more poorly in the Demonstration-plus-label version than in the Demonstration version on all four types of trials—(1) Attribute-color, 77% correct versus 87%; (2) Attribute-size, 55% versus 90%; (3) Dimension-color, 55% versus 70%; and (4) Dimension-size, 60% versus 75%. These results indicate that the mere addition of linguistic terms to a task may impair performance. This point has also been demonstrated by Siegel (1977) in a study of young children's understanding of quantity relations.

Experiment 3

The third experiment was conducted to examine more closely the relation between conceptual and linguistic development. Experiments 1 and 2 were replicated within subjects.

Method

Subjects.—The subjects were 10 2-year-olds (*M*, 2-6; range, 2-1 to 2-10); 10 3-year-olds (*M*, 3-3; range, 3-0 to 3-9); and 10 4-year-olds (*M*, 4-4; range, 4-0 to 4-10) from day-cares serving the same populations as those that participated in the first two experiments.

Stimuli and procedure.—The stimuli for the follow-the-leader task consisted of the Identity, Identity-Analogy, Attribute 1, and Dimension sets employed in Experiment 1. The stimuli for the Simon-says task consisted of the child's sets of these sets. The procedures in the two tasks were the same as those employed in Experiments 1 and 2. The specific instructions on the two new types of Simon-says trials (Identity and Identity-Analogy) were as follows: (1) Identity—"Simon says take the plane [car/giraffe/boy]"; (2) Identity-Analogy—"Simon says take two that are the same." Half the children at each age level participated in the follow-the-leader task first and half participated in the Simon-says task first. The children were tested individually in four to six 10–20-min sessions.

Results and Discussion

Identity and Identity-Analogy.—In the follow-the-leader task, all children achieved a level of performance equal to or above 75% correct on the Identity and Identity-Analogy trials. Mean proportion correct ranged from a low of .95 for 2-year-olds on Identity-Analogy trials to 1.00 for 4-year-olds on Identity trials. This high level of performance again demonstrates the transparency of the follow-the-leader task to young children. In the Simon-says task, all children succeeded on the Identity trials, the trials on which the children were asked to get specific objects by name. Mean proportion correct on these trials ranged from .98 (2-year-olds) to 1.00 (4-year-olds). Most children also succeeded on the Simon-says version of the Identity-Analogy trials, the trials on which the children were asked to "take two the same." If 75% correct is deemed as passing, eight 2-year-olds, nine 3-year-olds, and all 10 4-year-olds passed the Identity-Analogy trials of the Simon-says task. The three children who failed these trials all participated in the Simon-says task prior to participating in the follow-the-leader task.

Attributes and Dimensions.—Table 5 shows the number of children passing (achieving at least 75% correct) the Attribute and Dimension trials in the two tasks. The pattern of performances in the follow-the-leader task follows closely that observed in Experiment 1. Most 3-year-olds and all 4-year-olds successfully imitated object choices by both color and size attributes and by each dimension. However, whereas a majority of 2-year-olds succeeded in matching objects by specific colors and sizes, none consistently imitated choices of pairs of objects by either dimension. As in Experiment 1, the 2-year-olds' failures did not consist of random choices on the Dimension trials. Rather, the 2-year-olds primarily chose objects related on some dimension but chose objects by the relevant dimension (40% of the time), and by the irrelevant dimension (43% of the time), equally often, $t(9) < 1.00$. Thus, 2-year-olds again appear to have some understanding of attribute relations but do not appear to differentiate attributes into qualitative kinds. This result, along with the fact that no child passed the dimension task without also passing the attribute task, corroborates the conclusion from Experiment 1 that an understanding of attribute relations precedes an understanding of dimensions.

As is also evident in Table 5, the pattern of performances in the Simon-says or linguistic task replicates the findings of Experiment 2. Comprehension of the linguistic labels for color attributes increases with age, such that half the 2-year-olds and all the 4-year-olds can select objects by a named color. Comprehension of the instruction to take two the same color increases more markedly in this age range; no 2-year-old consistently chose same-colored objects in response to this instruction, whereas all the 4-year-olds did. In contrast to the pattern of results on the Color-Attribute trials, only a minority of the children at each age level passed the Size-Attribute trials. Performances on the Size-Dimension trials, however, are quite like those on the Color-Dimension trials. As in Experiment 2, then, when color is the relevant dimension, more children succeed (achieve 75% correct) on the Attribute trials than on the Dimension trials, $\chi^2(1) = 4.38, p < .05$, whereas the reverse is true when the relevant dimension is size, $\chi^2(1) = 4.44, p < .05$.

The special character of the Size-Attribute trials is highlighted by considering the relationship between performances in the conceptual and linguistic tasks. The distribution of children passing and failing the Size-Attribute trials is markedly different in the follow-the-leader and Simon-says task, $\chi^2(1) = 21.76, p < .01$; 87% of the children passed the conceptual task, but only 27% passed the linguistic task. On all other trial types, the distribution of children passing and failing did not differ reliably between the two tasks: Color-Attribute, $\chi^2(1) = .418, p > .50$; Color-Dimension, $\chi^2(1) = .064, p > .50$; Size-Dimension, $\chi^2(1) = 1.10, p > .25$.

The relationship between conceptual and linguistic knowledge is also illuminated by the conditional probabilities of children passing the linguistic task as a function of performance in the conceptual task. The probability of a pass on the Simon-says task given a fail on the follow-the-leader task was zero for all trial types. Obviously, one cannot comprehend dimensional terms unless one understands the relations to which they refer. The probability of a pass on the Simon-says task given a pass on the follow-the-leader task did vary as a function of trial type and is shown in Table 6. For all trial types except Size-Attribute, success on the conceptual task virtually assured success on the linguistic task. Apparently, color-attribute labels and the names for the color and size dimensions are rapidly linked to the corresponding concepts once these concepts are attained. However, the acquisition of the size-attribute labels severely lags behind the conceptual representation of these attributes and the ability to infer rules about these attributes.

As in Experiment 2, the children's overall failures on the Size-Attribute trials of the Simon-says task stemmed primarily from trials on which the children were to select the "short" object. Across all ages, the children correctly selected the tall object when they were instructed to do so 72% of the time, but correctly selected the short object when they were told to do so only 37% of the time. This asymmetry in correct selections of tall and short objects did not occur in the conceptual task. Children correctly imitated the selection of the tall object 88% of the

TABLE 5

NUMBER OF CHILDREN (of Ten) ACHIEVING AT LEAST 75% CORRECT FOR ALL CHILDREN AT EACH AGE LEVEL ON THE COLOR-RELEVANT AND SIZE-RELEVANT TRIALS OF THE TWO TASKS

	TASK							
	Follow the Leader				Simon-Says			
	Attribute		Dimension		Attribute		Dimension	
AGE (Years)	Color	Size	Color	Size	Color	Size	Color	Size
2..........	6 (.65)	6 (.70)	0 (.38)	0 (.42)	5 (.32)	1 (.40)	0 (.32)	0 (.40)
3..........	9 (.92)	10 (.92)	6 (.72)	10 (.85)	8 (.82)	3 (.60)	5 (.65)	6 (.72)
4..........	10 (.98)	10 (.98)	10 (.95)	10 (.95)	10 (.98)	4 (.62)	10 (.98)	10 (.95)
Total *N* passing...	25	26	16	20	23	8	15	16

NOTE.—Mean proportion correct is in parentheses.

time and correctly imitated the selection of the short object 85% of the time. The specificity of the asymmetry between tall and short to the linguistic task holds across all ages. Table 7 shows the proportions of objects chosen on the tall and short trials in the two tasks. At each age level children succeeded in imitating choices of the tall and the short object in the follow-the-leader task. In the Simon-says task, the children at each age level chose the tall object when verbally told to do so reliably more often than expected by chance, but at none of the three levels did children's correct choices of the short object reliably exceed the level expected by chance alone. These results strongly suggest that the generally observed asymmetry in young children's comprehension of the linguistic labels for the positive or more intensive attribute and the negative or less intensive attribute (see E. Clark, 1972) is specifically linguistic and is not a reflection of conceptual differences between attributes or cognitive strategies for performing a task (cf. Huttenlocher, 1974; Palermo, 1974).

TABLE 6

THE PROBABILITY THAT A CHILD PASSED (Achieved at Least 75% Correct) SPECIFIC LINGUISTIC (Simon-Says) TRIALS GIVEN A PASS ON THE CORRESPONDING CONCEPTUAL (Follow-the-Leader) TRIALS

	TRIAL TYPE			
	Color		Size	
AGE (Years)	Attribute	Dimension	Attribute	Dimension
2	.83	. . .	.17	. . .
3	.89	.83	.30	.60
4	1.00	1.00	.40	1.00
Across ages	.92	.94	.31	.80

TABLE 7

PROPORTIONS OF OBJECTS CHOSEN ON THE SIZE-ATTRIBUTE TRIALS AS A FUNCTION OF THE OBJECTS CHOSEN BY THE EXPERIMENTERS IN THE FOLLOW-THE-LEADER TASK AND AS A FUNCTION OF THE LINGUISTIC LABEL IN THE SIMON-SAYS TASK

	TASK			
AGE (Years) AND OBJECT	Follow the Leader		Simon-Says	
CHOSEN	Tall	Short	"Tall"	"Short"
2:				
Tall	*.75**	.15	*.55**	.40
Medium	.15	.20	.35	.35
Short	.10	*.65**	.10	*.25*
3:				
Tall	*.90**	.05	*.75**	.25
Medium	.10	.00	.15	.30
Short	.00	*.95**	.10	*.45*
4:				
Tall	*1.00**	.05	*.85**	.10
Medium	.00	.00	.15	.50
Short	.00	*.95**	.00	*.40*

NOTE.—Proportions of correct choices are given in italics.

* Correct choices significantly greater than expected by chance, $\chi^2(1)$, $p < .05$.

The asymmetry in the comprehension of "tall" and "short" should probably not be interpreted as indicating that the difficulties in the acquisition of the size-attribute labels are specific to "short." If passing is defined as two out of two correct trials (probability of a child passing by chance alone is .11), 46% of the children pass "tall" and 23% of the children pass "short." The tendency for more children to pass "tall" than "short" by this measure does not reach significance, $\chi^2(1) = 3.60, p < .10$. For comparison, two of the color-attribute trials in the linguistic task were randomly selected ("blue"/"green") and passing was again defined as two out of two correct trials. By this measure, 77% of the children pass the linguistic trials for color attributes—reliably more children than pass the trials measuring comprehension of "tall," $\chi^2(1) = 5.74, p < .025$. If performance is assessed in the identical manner on the identical trials of the follow-the-leader task, the percentages of children passing are 80%, 77%, and 80% for tall, short, and the selected color-attribute trials. Thus, in the linguistic task but not in the conceptual task, fewer children succeed on the trials involving both the more intensive and the less intensive size attribute than do on comparable trials involving color. This apparent greater difficulty with the word "tall" as well as the word "short" than with color-attribute labels is also evident in the conditional probabilities of a pass on the linguistic measure given a pass on the corresponding conceptual measure. The conditional probabilities are .50 for "tall" and .25 for "short." Both conditional probabilities are much smaller than that calculated for the selected color-attribute trials, which is .88 (and than those shown in Table 6 for the Dimension trials). Thus, although "tall" is understood prior to "short," the mappings of both these linguistic labels to their underlying concepts appear to pose special difficulties.

One more aspect of the results of this experiment merit mention. There were small but consistent effects of task order. A higher percentage of children passed each type of trial in the Simon-says task when this task followed the follow-the-leader task than when the order was the reverse (Color-Attribute, 93% vs. 60%; Color-Dimension, 60% vs. 40%; Size-Attribute, 47% vs. 7%; and Size-Dimension, 75% vs. 40%). In contrast, experience in the linguistic task did not facilitate performance in the conceptual task (percentage of children passing in the follow-the-leader task when it followed and preceded the linguistic task; Color-Attribute, 87% both orders; Color-Dimension, 47% vs. 60%; Size-Attribute, 73% vs. 93%; Size-Dimension, 67% vs. 75%). Apparently, the linguistic terms were more accessible to the children when they had previously played a nonverbal game involving the same stimuli and concepts. The accessibility of the basic concepts, in contrast, was not increased (but, if anything, was decreased) by previous experience in a similar verbal task.

In summary, the results of this experiment replicate the findings of Experiments 1 and 2. In conceptual development, an understanding of attribute relations precedes an understanding of the dimension. The mapping of linguistic terms to color concepts appears to occur fairly rapidly, and thus for these terms attribute labels are acquired before dimension labels. However, the acquisition of linguistic terms for size attributes is not complete for a long time after the acquisition of the basic concepts. In this case of size terms, then, the linguistic term for the dimension is understood before the terms for attributes. Thus the order in linguistic development is not isomorphic to that in conceptual development.

General Discussion

The results of the three experiments are pertinent to issues in the development of object comparison, the acquisition of linguistic terms, and the methods by which young children's knowledge may be assessed. Each of the issues is considered in turn.

Object Comparison

There is ample evidence that tasks requiring dimensional analysis are difficult for preschool children (Inhelder, Sinclair, & Bovet, 1974; Kemler, 1983; Miller, 1979; Shepp & Swartz, 1976; Smith, 1980; Tighe & Tighe, 1978). However, the implications of these results for how and whether children represent dimensional relations have been unclear. The present research sought to obtain new information about this issue by investigating children's understanding of dimensions. The results demonstrate two distinct levels in the initial understanding of the component relations between objects. The first level consists of the knowledge of attributes and the ability to represent attributes as separate from the objects that possess them. The second level consists of the organization of attributes into dimensions. These conclusions rest on the finding that without feedback or instruction, 2-year-olds spontaneously imitate object choices by component attributes but not by dimensional relations, whereas 3- and 4-year-olds spontaneously imitate object choices by both attributes and dimensions. Quite young children, then, represent objects dimensionally, and that representation appears composed of separable components.

The level of performance of the children raises questions about the source of older children's (5-, 6-, and 7-year-olds) usual difficulties in dimensional-comparison tasks (e.g., Kemler, 1983; Kendler, 1979; Shepp et al., 1980; Ward, 1980). The dimensional representation of objects and the making of inferences from those representations require the perceptual analysis of stimulus objects into dimensional constituents. Three- and 4-year-olds thus possess the perceptual skills often said to be lacking in older children. Even the 2-year-olds showed some dimensional-analysis ability, as many were able to match objects on an attribute. This level of performance by the 2-year-olds contrasts sharply with the reported difficulties of 5- and 6-year-olds in tasks requiring attribute matches (see e.g., Kemler & Smith, 1978; Smith, 1979, 1980).

If such young children are able to analyze multidimensional objects, why are many dimensional-analysis tasks so difficult for them? Two, not mutually exclusive, possibilities are of theoretical interest. First, although a young child might possess well-developed concepts of particular attributes and dimensions, he or she might prefer not to use these relations but prefer instead to compare objects by some other kind of relation, such as overall similarity (see Shepp et al., 1980; Smith, 1979; Smith & Kemler, 1977). Baron (1978; see also Smith & Baron, 1981) has suggested that comparing objects in terms of their dimensional constituents rather than wholistically is a strategic behavior under voluntary control. The young child, then, may fail to use dimensional relations because he or she does not intentionally invoke a strategy appropriate to the task, even though the basic ability to use that strategy is available. By this interpretation, strong dimensional-comparison abilities were observed in the present study because the follow-the-leader task made the need to strategically attend to the components of objects apparent to the children.

A second possible limitation on the use of attribute and dimension concepts concerns the ease of the processing necessary to abstract component attributes and dimensions. The evidence from school-age children in reaction-time tasks is clear; the younger the child the longer it takes for stimuli to be analyzed into attributes (Kemler & Smith, 1978; Shepp & Swartz, 1976; Smith, 1980). The children's style of performance on the attribute and dimension trials of the follow-the-leader task is consistent with this view that cognitive effort is required for children to attend to component attributes and dimensions. The children did not choose objects quickly. Rather, the children appeared to be working very hard—looking back and forth from the experimenters' choices to their own sets and often fingering several objects before making a final selection. Thus, young children may possess usable attribute and dimension concepts but have difficulties in separately processing attributes and dimensional relations. These difficulties may be insurmountable in certain cognitive tasks that, unlike the follow-the-leader task, place heavy processing demands on memory or that impose time constraints.

Regardless of whether the young child's use of attributes and dimensions is hampered by strategy factors, processing difficulties, or both kinds of limitations, the present results show that the basic concepts are available to quite young children. The notion of component attributes is sufficiently strong in 2-, 3-, and 4-year-olds and the notion of a dimension sufficiently strong in 3- and 4-year-olds that these children (albeit perhaps with cognitive work) spontaneously imitate object choices by these relations. Attributes as separate constituents of objects and dimensions as distinct kinds of attribute relations are unquestionably present in the preschool child's conceptual system.

The present results thus extend previous findings about the development of object comparison in two ways. First, the results show that very young children have the perceptual skill to analyze objects into dimensional constituents, and that they possess some understanding of dimensional relations. Second, the results show that understanding grows in two steps—early in development the child represents attributes, later these attributes are organized into dimensions. Further tests of this distinction between attribute and dimension knowledge would be useful, particularly with dimensions more related to each other than color and size. Related dimensions such as the height and width of objects or the length and density of an array of objects may be understood as separate dimensions fairly late in development. Still, the first level of understanding may involve only separate attributes without any differentiation of the attributes as to kind.

The Acquisition of Dimensional Terms

A conceptual understanding of attributes and dimensions almost certainly plays a critical role in linguistic development, although probably not a simple one. A variety of factors may influence the speed with which young children acquire a particular word, including the acquisition of the underlying concept to which the word is to be mapped, the linguistic role or roles of the word in the language, and the frequency of the use of the word in speech to young children (see Slobin, 1973). The present results suggest that the acquisition of the labels for color attributes and the labels for the color and size dimensions is primarily constrained by the acquisition of the underlying concepts. In these three cases, the acquisition of the words lags only briefly behind the acquisition of the concepts. However, the acquisition of the labels for the two size attributes clearly involves more than the acquisition of the concepts. Two-year-olds are able to match objects by and infer rules about tall and short, yet many 4-year-olds do not have a mature understanding of the words "tall" and "short." Further, a marked asymmetry in the comprehension of "tall" and "short" was observed—an asymmetry that has been the focus of much research in language acquisition (e.g., Bartlett, 1976; E. Clark, 1972; Donaldson & Wales, 1970). No such asymmetry was observed in the conceptual task. The asymmetry seems to be, then, as it was initially conceived (Bierwisch, 1967; E. Clark, 1973)—specifically linguistic.

Why should the acquisition of some dimensional terms follow the acquisition of the concepts so quickly while others lag so far behind? A number of linguistic factors may be critical (see, e.g., Carey, 1978; E. Clark, 1972). For example, the linguistic advantage of "tall" over "short" may be due to the fact that "tall" plays two linguistic roles—as the label for the more intensive attribute and as a general label for the dimension of vertical size (see E. Clark, 1972; H. Clark, 1970). An additional factor that may determine the ease with which linguistic labels are mapped to concepts may be the directness of the mapping. A label such as "red" correctly applies to a given object regardless of the context in which that object is considered. The labels "same color" and "same size" also correctly apply to a given pair of objects regardless of context. These labels depend on fixed properties of individual objects. However, the actual size of an object does not by itself determine whether the object should be labeled "tall" or "short." An object that is "tall" in one context may be properly labeled "short" when viewed in the context of other extremely tall objects. The indirectness of the mapping of certain attribute labels to the fixed attributes of objects may hinder the acquisition of these terms. Thus, the labels for ordinal attributes, because of their inherent comparative nature, may pose particular difficulties for the young child trying to acquire these linguistic terms.

Methodological Issues

The particular conceptual measure used merits discussion. Prior to the collection of pilot data, it was not at all clear whether the follow-the-leader task would work. There are a host of possible reasons why young children, regardless of the character of their dimensional concepts, might have failed to perform the task. According to one traditional theory of early cognition, the follow-the-leader task should not have worked. To succeed, the child was required to induce object-choice rules from demonstrations. The rules to be inferred were often abstract—not about concrete particulars but rather about kinds of relations. Within the Piagetian framework, inferential skill and the coordination of or operation on concrete representations to form rules is the province of the concrete-operational period (see Inhelder & Piaget, 1964; Piaget, 1928, 1971). The children who participated in the present study are likely to be preoperational by standard Piagetian measures, yet these children were well able to "coordinate" the concrete particulars and form abstract rules. The level of success of the children in the follow-the-leader task thus adds to a growing list of empirical results showing the precocious emergence of seemingly sophisticated conceptual skills (see, e.g., Brainerd, 1979; Gelman, Bullock & Meck, 1980; Jusczyk & Earhard, 1980; Siegel, McCabe, Brand, & Matthews, 1978; Trabasso, 1977).

Given that the follow-the-leader task does work, it provides a potentially powerful technique for assessing young children's concepts. First, the task is understandable to very young children. The urge to imitate, whatever its underlying nature, is very strong. Second, the task is language-free. Studies of conceptual development often involve in one way or another asking a child what he or she knows. As others have remarked (e.g., Braine, 1959; Siegel, 1977), such methods may reveal more about language than conceptual development. As the present results indicate, developmental trends in language knowledge may not even provide an indirect measure of developmental trends in underlying concepts. Moreover, the mere use of words not well understood by young children may, as in the pilot study, mask conceptual skills. The follow-the-leader task circumvents these problems because the task is clear to young children without verbal instruction. Such a language-free measure may also aid studies of language acquisition by helping to pinpoint the limits on the acquisition of word meanings as conceptual or due to some other factor.

Conclusion and Summary

The results suggest that the notion of a dimension, that is, of qualitatively distinct kinds of stimulus difference, is not given but develops early and is part of the child's usable conceptual knowledge at age 3. The ability to represent attributes and to infer rules about attributes is evident in even younger children. These conclusions contrast with those derived from findings showing that older children have difficulties in using attribute and dimension relations in problem-solving tasks. The results also suggest that very young children possess abstract reasoning skills. Two-year-olds successfully complete analogies of the following sort: a large red house is to a large red house as a small white flower is to a small white flower as a ——— is to a ———. These insights into children's understanding of relations derive from the use of a nonverbal task that is well understood by very young children. Such a task is of considerable potential value both for studying conceptual development and for studying linguistic development. The comparison of conceptual and linguistic knowledge in the present experiments suggests that the comprehension of some linguistic terms is primarily constrained by conceptual factors, whereas others may be primarily limited by linguistic factors.

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