Children’s Use of Frames of Reference in Communication of Spatial Location

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Giving directions to someone about how to get somewhere or how to find something is a common everyday task. Yet it is interestingly complex. Communicating information about spatial location is challenging for children because two different types of information, spatial and verbal, must be coordinated. This activity requires at least: (1) accessing one’s spatial knowledge about the target location, (2) selecting information from the environment that will distinguish the target location from other locations, and (3) linguistically encoding that information in a message that takes into account the knowledge and capacity of the listener. These processes have been isolated and studied in various forms by researchers interested in spatial cognition (e.g., Piaget & Inhelder, 1967; Piaget, Inhelder, & Szeminska, 1960; for a recent review, see Cohen, 1985), psycholinguistics (e.g., Johnston, 1981; Klein, 1982; Linde & Labov, 1975), and referential communication (e.g., Glucksberg, Krauss, & Higgins, 1975; Sonnenschein, 1988).

Spatial direction-giving is a form of referential communication in which the goal is to enable the listener to distinguish a target location or route (the referent) from all possible alternatives (nonreferents). Few empirical studies of the development of referential communication skills have been explicitly concerned with spatial reference. Instead, most developmental referential communication studies have been concerned with distinguishing a target stimulus (typically, a word or graphic shape) from a set of similar items. This work has been strongly influenced by Piaget’s (1929) contention that young children are egocentric (i.e., unable to accommodate the perspective of a listener in a communication situation). On both empirical and theoretical grounds, reviewers of this literature conclude that the attempt to relate develop-
mental improvements in communication accuracy to an increasing ability to analyze the listener’s perspective has not proven very fruitful (Asher, 1979; Glucksberg et al., 1975; for a meta-analysis of this literature, see Dickson, 1982). More recent work in this area has emphasized the component skills required for successful communication in specific tasks (e.g., Asher, 1976; Ford & Olson, 1975; Sonnenschein, 1968; Sonnenschein & Whithurst, 1984). These studies suggest that poor communication is often due to the child’s failure to adequately compare potential messages specifying the referent with those specifying nonreferents.

In general, this work has focused on the identification of objects by reference to their intrinsic attributes (such as size, shape, or color). However, a referent can also be distinguished from nonreferents by its extrinsic attributes, for example, its location relative to other objects within the environment. Clearly, both techniques are employed in everyday life. The latter strategy is particularly useful when the referent object and nonreferents are not easily distinguished on the basis of their appearance. Although verbal reference to spatial location has been investigated in studies of children’s spatial direction-giving, this research has focused primarily on directions specifying large-scale routes (e.g., Gauvain & Rogoff, 1989; Plumert, Marks, & Pick, 1988; Vanetti & Allen, 1988; Weller & Harris, 1988; Weissenbom, 1980). Like referential communication studies, these have been concerned with developmental changes in the effectiveness of children's directions and the cognitive and linguistic changes underlying these developments. The focus of spatial direction-giving research has been on how children organize their directions. For example, studies have examined whether children employ the convention, typically used by adults, of taking the listener along an imaginary walk when describing a large-scale space (Gauvain & Rogoff, 1989).

Spatial directions can also be analyzed on a more specific level, in terms of the spatial relations they express and the reference objects they include. Researchers in psycholinguistics have investigated young children’s ability to comprehend and produce spatial relational terms such as in, on, in front of, behind, below, between, etc. (e.g., Clark, 1980; Johnston & Slobin, 1979; Kuczaj & Maratosos, 1975; Tanz, 1980). However, there has been no research to date on what kinds of reference objects children spontaneously use in their utterances about location, or whether they use them correctly. Instead, the literature on reference objects in children’s statements about location has focused on how characteristics of reference objects influence children’s understanding and use of spatial relational terms. For example, Kuczaj and Maratosos (1975) examined the relation between whether an object has an intrinsic front or back and young children’s comprehension and production of front, back, and side.

In contrast to work in developmental psycholinguistics, several studies of the development of spatial cognition have investigated the reference objects that children use in order to remain oriented in a space. Researchers have distinguished between three spatial reference systems, or frames of reference, that define spatial position with respect to (1) the self, (2) other persons, and (3) environmental landmarks (Pick, Yonas, & Rieser, 1979). By placing different frames of reference in conflict and observing which ones children rely on to perform way-finding or object-relocation tasks, researchers have inferred developmental trends from reliance on self-reference to the use of other- and landmark-based frames of reference, and from reliance on proximal landmarks to increasingly distal ones (e.g., Acerdolo, 1976, 1977; Acerdolo, Pick, & Olsen, 1975; Allen & Kirasic, 1988; Hart & Moore, 1973; for a review, see Pick et al., 1979). Children’s increasing competence in spatial orientation tasks is de-
scribed in terms of the reference system used. As Pick et al. (1979, p. 130) note, environmental landmarks are more important than animate reference objects like oneself or other people when the goal is to remain spatially oriented while moving through a space. Similarly, when the task involves remaining oriented in an enclosed space, more distal (and typically larger) environmental landmarks (e.g., the walls of a room) are also less likely to change position than are the proximal landmarks contained within the space (e.g., furniture) and are consequently more reliable. Pick et al. propose that as children broaden their attentional focus with age they become capable of using increasingly distant reference objects.

The present study represents a new approach to the systematic investigation of the development of verbal communication about spatial location. The aim of the study was twofold: (1) to examine developmental change in children’s use of frames of reference in a small-scale spatial direction-giving task, and (2) to compare the effectiveness of children’s directions in environmental contexts that differed in the availability of potential reference objects. Four-, 6-, and 8-year-old children attempted to specify verbally which of several identical cups contained a hidden object. Children in one condition sat across from an adult listener in a room that had a wide variety of potentially informative reference objects, specifically, the child, the listener, and distinctive landmarks proximal and distal to the cup array. In the second condition, only the child and “the listener could be used to construct an effective direction—the landmarks, while present, no longer differentiated opposite sides of the room or the cup array.

The effectiveness of directions was expected to increase with age. The spatial reference systems literature and studies of the order of acquisition of spatial terms suggested two predictions about developmental trends in the use of reference objects. First, the notion of a developmental shift from self- to other- or landmark-based frames of reference suggested that the frequency of self-reference in spatial directions would decline with age relative to other frames of reference. This prediction, however, seemed less likely to hold for directions about the lateral dimension of the cup array in the present task. Because the ability to use left and right is particularly difficult for children and develops after other (front-back and up-down) spatial relational terms (Harris, 1972), young children might not attempt to use themselves or the listener as reference objects when communicating about the lateral dimension (e.g., “It’s on my/your left”). This implied that the effectiveness of younger subjects’ directions about the lateral dimension would depend on their ability to use differentiating landmarks in place of left and right. Second, the notion of a proximal-to-distal shift suggested that with differentiating landmarks present, younger children would be limited to using reference objects proximal to the target location. Older children, in contrast, should be able to incorporate a greater proportion of distal reference objects in their directions.

**Experiment 1**

**METHOD**

**Subjects**

Subjects were 20 preschoolers from a university laboratory nursery school and 20 first graders and 20 third graders from a middle-class metropolitan public school. There were equal numbers of boys and girls in each experimental condition. Mean ages of the groups were: 4-7 (range: 3-11 to 5-3), 6-8 (range: 6-2 to 7-4), and 8-8 (range: 8-4 to 9-5).

**Design**

Each child attempted to specify verbally the location of a hidden toy in one of two experimental conditions. Ten of the children in each age group gave directions in a differentiated condition, which offered a rich assortment of distinctive markings that potentially could be related to the hiding location. The other half of the children gave directions in an undifferentiated condition, which had similar but nondistinctive markings.

**Apparatus**

The experimental room, shown in Figure 1, measured 14 x 7 feet (4.27 x 2.13 m) and was constructed of uniform white panels, remote from the subject. Thus, a self reference system is a very proximal one. However, the proximal-distal distinction can also be made in relation to the focus of the task. Thus, for a task in which the goal is to orient the self, proximal does mean close to the self. The focus of the task in the studies described below is a hiding location across the room from the subject. Therefore, in this discussion, proximal will be used to mean close to the focus of the task and distal will be used to mean far from the focus of the task. As will be seen, in this sense in this study, a self reference system would also be a distal one.
Differentiated and undifferentiated experimental conditions differed in the distinctiveness of the colors of curtains in the doorways and the colors of strips of tape on the edges of the table. In the differentiated condition, opposite sides of the table and room were marked by tape or curtains of different colors. In the undifferentiated condition, opposite sides of the room and table were marked with the same colors (see Fig. 1).

Procedure

A second adult experimenter, the “observer,” told each subject that he or she would be playing a number of hiding and finding games in which the observer would help the child hide a small toy under one of a number of cups while the listener was out of the room. After the toy was hidden, the child took the seat across the room from the table, and the listener was called back into the room. The observer then stood slightly behind and to the child’s right side while the child gave directions to the listener.

The child was given the instructions: “Tell [the listener’s name] where the toy is so he can find it as quickly as possible.” Children were instructed not to point to the toy’s location. If the listener judged the child’s first verbal direction in each trial to be effective, the toy was revealed and the child praised. If the child’s direction was inadequate to specify the toy’s location precisely, the listener prompted the child to provide more information or try again (e.g., “I can’t find it yet. Can you tell me something else about where it is?”). If the direction was still ineffective after two such prompts, the listener “guessed” at the toy’s location, basing the choice as closely as possible on the information the child had given. If the “guess” was incorrect, the child was then given a chance to supplement the direction further. Eventually, the listener revealed the toy, and the child was praised for his or her efforts.
There were 16 trials, including all possible hiding locations in five different cup arrays. Each array required the child to specify the target object’s location with reference to either one or two of the following dimensions of the cup array: front-back (FB), left-right (LR), and middle-end (ME). The five cup arrays and the kinds of spatial distinction subjects needed to make for each array are shown in Figure 2.

Subjects were first given two easy practice trials, in which the toy was hidden under one of a pair of differently colored cups arranged as in array 2 (see Fig. 2). All subjects performed both practice trials correctly. Because pilot work had indicated that some arrays were quite difficult for preschoolers, the order of presentation was designed so that the youngest subjects would not be overly discouraged early in the session if they failed to give effective directions for difficult arrays. Thus, all subjects received the cup arrays in the same order, shown in Figure 2.

Coding and Analysis

Each child’s directions for all 16 trials were transcribed from audiostreamtape recordings. The present report is based on the coding of subjects’ directions prior to any prompting. Two of the authors coded subjects’ directions on each of the 16 trials for effectiveness and for the types of reference objects used. For all five cup arrays, a direction was coded as effective if the subject unambiguously specified the target location with respect to all the relevant dimensions (some combination of FB, LR, and ME) for that array. In addition, codings for effectiveness were done separately for the FB and LR dimensions of the four-cup 2 x 2 array (array 5, Fig. 2).

The types of reference objects included: (1) Self (“it’s on my right hand”); (2) Listener (“it’s the one on your side”); (3) Tape (“the one near the red tape”); (4) Curtains (“by the red curtain”); (5) Cup Array (“it’s one of the ones in the middle”); (6) Object-inside (an object inside the experimental room, “it’s by the leg on the table”); (7) Object-outside (an object outside the experimental room, “it’s on the same side as the parking lot”); (8) Nonspecific (coded when the child apparently tried to use a reference object, but the
coder was unable to determine which type: “by the blue” or “one of the cups on the left”). Reference points were coded as present regardless of whether the direction was effective.

Reliability for each variable was determined by dividing the number of trials that the coders scored identically by the total number of trials coded for six randomly selected subjects (10% of the sample). Percent agreement for the effectiveness variable was 85%; agreement for eight reference-point variables ranged from 75% to 100%, with a mean of 92%. Only the nonspecific variable had an intercoder reliability less than 80%.

RESULTS AND DISCUSSION

Effectiveness

Figure 3 shows the mean percentage of effective directions across all 16 trials for each age group in the two differentiation conditions. A 3 (age) × 2 (differentiation condition) × 2 (sex) ANOVA for effectiveness revealed significant main effects of age, $F(2,48) = 40.91$, $p < .001$, condition, $F(1,48) = 5.03$, $p < .05$, and sex, $F(1,48) = 6.23$, $p < .05$, MS error = 9.31. Post hoc tests (Tukey’s HSD, alpha = .05) indicated that the percentage of effective directions differed for all age comparisons (4-year-olds, 19%; 6-year-olds, 50%; 8-year-olds, 72%). Effectiveness was higher in the differentiated condition than in the undifferentiated condition (53% and 42%, respectively), and girls gave a higher proportion of effective directions than boys (53% and 41%, respectively). These results are consistent with our hypothesis of general improvement with age and indicate that children performed better when distinctive landmarks were present.

Effectiveness for the FB and LR dimensions.—Two analyses examined the hypothesis that children would have more difficulty communicating about the left-right than the front-back dimension. Because the cup arrays differed in number of cups and thus in the number of dimensions that had to be coordinated on any given trial, these analyses also included an array type variable. This allowed us to examine whether children had more difficulty with the relatively complex four-cup arrays than the two-cup arrays. The first analysis compared effectiveness for the LR and FB two-cup arrays (arrays 1 and 2) with effectiveness for the LR and FB dimensions of the four-cup 2 × 2 array (array 5; see Fig. 2). This was a 3 (age) × 2 (differentiation condition) × 2 (dimension: FB vs. LR) × 2 (array type: two-cup vs. four-cup 2 × 2) ANOVA with repeated measures on the last two factors. The second analysis was identical to the first, except that it compared effectiveness for the LR and FB two-cup arrays with effectiveness for the LR and FB four-cup linear arrays (arrays 3 and 4 in Fig. 2). Both analyses were conducted on the mean percentage of effective directions.

The first analysis revealed a main effect of age, $F(2,54) = 23.19$, $p < .001$, and a significant age × dimension interaction, $F(2,54) = 3.43$, $p < .05$. There were no significant effects for the array type factor, indicating that children performed as well in specifying the FB and LR dimensions for the four-cup 2 × 2 array as they did in specifying location for
these dimensions in the two-cup arrays. Post hoc comparisons (Tukey’s HSD, alpha = .05) showed that 4-year-olds gave significantly better directions about the FB dimension than the LR dimension (49% and 0.1%, respectively). In contrast, the mean scores on the FB and LR dimensions did not differ significantly for 6-year-olds (71% and 47%, respectively) or for 8-year-olds (86% and 74%, respectively). Eight-year-olds gave significantly better directions than the 4-year-olds on both the FB and LR dimensions. Six- and 8-year-olds’ mean scores did not differ, however. Six-year-olds gave a greater percentage of effective directions than the 4-year-olds for the LR dimension (47% and 0.1%, respectively), but their mean scores for the FB dimension did not differ significantly (71% and 49%, respectively). These results indicate that communicating about the two-cup LR arrays was particularly difficult for the 4-year-old children.

The second analysis compared effectiveness for the two-cup and four-cup linear arrays (in Fig. 2, arrays 1—4). This analysis revealed main effects of age, $F(2,54) = 27.92, p < .001$, differentiation condition, $F(1,54) = 5.13, p < .05$, dimension, $F(1,108) = 56.06, p < .001$, array type, $F(1,108) = 5.10, p < .05$, and a significant age $\times$ dimension $\times$ array type interaction, $F(2,108) = 3.6, p < .05$. Post hoc comparisons (Tukey’s HSD, alpha = .05) showed that the mean score for 8-year-olds (77%) was significantly greater than that for 4-year-olds (26%) but not significantly different from that for 6-year-olds (54%). Performance was higher in the differentiated condition (59%) than in the undifferentiated condition (46%). Children gave a greater percentage of effective directions for FB arrays than for LR arrays (68% and 36%, respectively) and for the two-cup than for the four-cup arrays (56% and 49%, respectively).

Table 1 shows the data, collapsed for differentiation condition. Because Tukey’s HSD test is unnecessarily conservative when there are a large number of means to compare (Hays, 1981), the three-way interaction was analyzed using the Newman-Keuls post hoc comparisons test (alpha = .05). On the FB two-cup array, the mean score of 8-year-olds was significantly higher than that of 4-year-olds but not significantly different from that of 6-year-olds. Six- and 8-year-olds’ scores on the FB four-cup array did not differ significantly but were both significantly higher than that of 4-year-olds. On both the LR two-cup and the LR four-cup arrays, 8-year-olds’ mean scores were significantly higher than those of 6-year-olds, which in turn were significantly higher than those of 4-year-olds.

Scores for the LR two- and four-cup linear arrays did not differ significantly for any age group, nor did scores for the FB two- and four-cup arrays. The mean scores for 4- and 6-year-olds were significantly higher on both types of FB than LR arrays. These results suggest that the LR dimension was particularly challenging for the 4- and 6-year-old children. The results also indicate that 8-year-olds had more difficulty with the LR four-cup linear array than with the FB arrays. Although 8-year-olds’ performance on the LR two-cup array did not differ from the FB two- or four-cup arrays, their mean scores on both FB arrays were significantly greater than that on the LR four-cup array.

Landmarks and effectiveness for the LR dimension.—To test the prediction that young children would communicate more successfully about LR relations when differ-

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>EXPERIMENT 1: MEAN PERCENT EFFECTIVE DIRECTIONS AS A FUNCTION OF AGE, DIMENSION, AND ARRAY TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIMENSION/ARRAY TYPE</strong></td>
<td><strong>Front-Back</strong></td>
</tr>
<tr>
<td><strong>AGE GROUP</strong></td>
<td>2 Cups</td>
</tr>
<tr>
<td>4 years (n = 20)</td>
<td>55 (46)</td>
</tr>
<tr>
<td>6 years (n = 20)</td>
<td>72 (30)</td>
</tr>
<tr>
<td>8 years (n = 20)</td>
<td>82 (29)</td>
</tr>
</tbody>
</table>

NOTE.—Standard deviations are in parentheses.
Differing landmarks were available, three planned comparisons were done on the mean percentage of effective directions for LR arrays (arrays 2 and 3; total number of trials = 6) in the differentiated and undifferentiated conditions. The results showed that 6-year-olds gave a greater proportion of effective directions in the differentiated than in the undifferentiated condition (47% and 18%, respectively, t(19) = 2.35, p < .05). In contrast, neither 4- nor 8-year-olds gave a greater proportion of effective directions in the differentiated than in the undifferentiated condition (4-year-olds, 8% and 0%; 8-year-olds, 68% and 63%, respectively). Thus, it seems that while 4-year-olds were unable to make use of the presence of distinctive landmarks to specify the LR dimension, 6-year-olds benefited from these landmarks. Eight-year-olds, in turn, were able to produce as many effective directions in the absence of distinctive landmarks as they did when landmarks were available. This suggests that they used themselves or the listener as reference objects in order to specify the lateral dimension.

Use of Reference Object Types

The major aim of this study was to investigate age-related changes in the types of reference object used in spatial directions. That is, was the increase in the number of effective directions with age reported above accompanied by the implementation of a single strategy of reference object use, or was there a shift in strategy with age?

The number of trials (total number trials = 16) in which each child used a given type of reference object was calculated. Because the overall frequency of reference object use varied with age (4-year-olds, M = 19; 6-year-olds, M = 26; 8-year-olds, M = 25), analyses were conducted on proportional use of reference object types computed for each subject. Mean percent data are presented in Table 2. These were analyzed using the multivariate approach for repeated measures (O’Brien & Kaiser, 1985).

The MANOVA included three between-subjects factors, age (3) × differentiation condition (2) × sex (2), for the eight types of reference objects. There were significant multivariate main effects of age, $F(14, 96) = 3.32, p < .001$, condition, $F(7, 48) = 4.03, p < .001$, and a significant multivariate age × condition interaction, $F(14, 96) = 2.55, p < .005$. The univariate tests for the eight reference object types and post hoc comparison tests (Tukey’s HSD, alpha = .05) are reported below.

Self

The univariate ANOVA for self references revealed a significant main effect of age, $F(2, 54) = 6.55, p < .005$, and a significant age × condition interaction, $F(2, 54) = 3.20, p < .05$. Post hoc tests showed that the proportion of directions in which 8-year-olds used themselves as reference objects (22%) was significantly greater than that for both 6-year-olds (14%) and 4-year-olds (9%). The mean scores for 6- and 4-year-olds did not differ significantly. In addition, 8-year-olds used themselves as a reference object significantly more often in the undifferentiated than in the differentiated condition. The means for 4- and 6-year-olds in the two differentiation conditions did not differ (see Table 2).

Listener

The univariate ANOVA for use of the listener revealed a significant main effect of age, $F(2, 54) = 3.98, p < .05$. Post hoc tests showed that the percentage of directions in which 8-year-olds used the listener as a reference object (27%) was significantly greater than that for 4-year-olds (15%), but did not differ significantly from that for 6-year-olds (20%). Use of listener did not differ significantly for 4- and 6-year-olds. The data in Table 2 indicate that reference to the listener occurred in a relatively high proportion of directions for each age group. The reasons for this were examined in Experiment 2, reported below.

Landmarks

Tape.—The univariate ANOVA for use of the proximal tape landmark revealed a significant main effect of condition, $F(1, 54) = 4.78, p < .001$, and a significant age × condition interaction, $F(2, 54) = 3.92, p < .005$. Children referred more to the tape in the differentiated than in the undifferentiated condition (15% and 2%, respectively). Eight-year-olds referred to the tape more often in the differentiated than in the undifferentiated condition, but use of tape in the two differentiation conditions did not differ significantly for either the 4- or 6-year-olds (see Table 2).

Curtain.—The univariate ANOVA for references to the distal curtain landmark revealed significant main effects of age, $F(2, 54) = 6.11, p < .005$, condition, $F(1, 54) = 4.78, p < .05$, and a significant age × condition interaction, $F(2, 54) = 6.19, p < .005$. Six-year-olds referred to the curtains in a greater percentage of their directions than did either the 4- or 8-year-olds (11%, 3%, and 3%, respectively). The curtains were used more in the differentiated than undifferentiated condition...
TABLE 2

EXPERIMENT 1: MEAN PERCENT DIRECTIONS INCLUDING REFERENCE OBJECTS AS A FUNCTION OF AGE AND DIFFERENTIATION CONDITION

<table>
<thead>
<tr>
<th>AGE GROUP/CONDITION</th>
<th>Self</th>
<th>Listener</th>
<th>Tape</th>
<th>Curtain</th>
<th>Cup</th>
<th>Array</th>
<th>Obj. In</th>
<th>Obj. Out</th>
<th>Nonspecific</th>
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<tr>
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<td>17</td>
<td>8</td>
<td>1</td>
<td>39</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
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<tr>
<td>(12) (13) (15) (3)</td>
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<td></td>
<td>(19)</td>
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<td>3</td>
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<td>17</td>
<td>11</td>
<td>18</td>
<td>26</td>
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<tr>
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<td>4</td>
<td>3</td>
<td>32</td>
<td>9</td>
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<td>1</td>
<td>14</td>
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<tr>
<td>(10) (12) (7) (7)</td>
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<td>(15)</td>
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<tr>
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NOTE.—Standard deviations are in parentheses.

(8% and 3%, respectively). Analysis of the age \times \text{condition} interaction showed that 6-year-olds used the curtains more than either the 4- or 8-year-olds in the differentiated condition. Reference to the curtains was quite infrequent for the 4- and 8-year-olds and did not differ significantly for the two differentiation conditions (see Table 2).

Proximal-to-distal shift.—Three planned comparisons compared the mean number of directions (out of 16) containing references to the proximal tape with the mean number of directions containing references to the distal curtains. These analyses were conducted within each age group on directions made by subjects in the differentiated condition. Four-year-olds' reference to the tape and curtains was infrequent and the means did not differ significantly (1.6 and .3, respectively). There was no significant difference in the means for 6-year-olds’ references to the tape and curtains (3.3 and 5.1, respectively). Eight-year-olds, in contrast, used a significantly greater number of tape than curtain references (6.6 and .9, respectively; $t(9) = 3.596, p < .005$).

Thus, by 6 years of age, children were able to incorporate the distal curtains into their directions. Interestingly, while 6-year-olds in the differentiated condition referred to the curtains in a greater proportion of their directions than the 4-year-olds, they also used a greater proportion of curtain references than the 8-year-olds. Presumably the 8-year-olds were also capable of using the distal curtains in their directions. However, they did so infrequently and showed a strong preference for using the proximal tape.

Use of landmarks for the LR dimension.—Would young children's difficulty in using left and right lead them to attempt to specify left-right relations by referring to landmarks rather than to themselves or their listener? Six planned comparisons tested whether the percentage of directions containing references to landmarks (curtains + tape) differed from percentage use of person references (self + listener) within each age group. These comparisons were conducted independently for directions given in the differentiated condition on linear FB arrays (arrays 1 and 4 in Fig. 2) and linear LR arrays (arrays 2 and 3 in Fig. 2). For FB arrays, 4- and 6-year-olds used significantly more person references than landmark references (4-year-olds: $M = 21\%$ and 4\%, respectively, $t(9) = 1.98, p < .05$; 6-year-olds: $M = 44\%$ and 16\%, $t(9) = 3.07, p < .01$). For LR arrays, 4-year-olds' use of both landmark ($M = 10\%$) and person ($M = 1\%$) references was infrequent and did not differ significantly. In contrast, 6-year-olds used landmark references for LR arrays ($M = 33\%$) significantly more often than person references ($M = 3\%$, $t(9) = 4.01, p < .005$). Eight-year-olds' use of landmark and person references did not differ significantly for either FB arrays (20\% and 33\%, respectively) or for LR arrays (23\% and 28\%, respectively).
indicating a mixed strategy for the specification of both dimensions.

Cup Array

References to the cup array (e.g., "it's in the middle" or "it's next to the one on the end") were used in a high percentage of directions at all ages and showed no effect of age or differentiation condition (see Table 2).

Objects-Inside and Objects-Outside

The univariate ANOVA for references to objects in the room revealed a significant main effect for differentiation condition, $F(1,54) = 6.72, p < .05$. As might be expected, children used a higher proportion of references to objects in the room (usually the observer) in the undifferentiated condition (5%) than in the differentiated condition (0%).

Nonspecific

The univariate ANOVA for nonspecific references revealed a significant main effect for age, $F(2,54) = 12.23, p < .001$. Post hoc tests showed that the percentage of directions with inadequately specified reference objects was significantly greater for 4-year-olds (32%) than for both 6- (13%) and 8-year-olds (8%). Use of nonspecific reference objects by 6- and 8-year-olds did not differ significantly.

Reference Use for LR and FB Dimensions

The results of the planned comparisons on use of landmarks versus person references for the FB and LR dimensions, reported above, suggest that dimension is an important factor in determining the reference objects that children incorporate into their directions. Four- and 6-year-olds used more person than landmark references for FB arrays, and 6-year-olds showed the opposite pattern for LR arrays. An additional multivariate analysis on proportional use of self, listener, landmark (tape and curtain combined), and nonspecific reference objects examined whether the dimension of the cup array (FB, LR) and the presence or absence of distinctive landmarks influenced the frequency of use of particular reference object types. This was a $3 \times 2$ (differentiation condition) $\times 2$ (dimension: FB vs. LR, arrays 1-4) MANOVA with repeated measures on the last factor. Percentages were computed without including the cup array references since our interest was in the use of reference objects external to the cup array itself. The data are shown in Table 3. There were significant multivariate main effects of age, $F(6,102) = 6.07, p < .001$, of dimension, $F(4,50) = 22.33, p < .001$, and a significant age $\times$ dimension interaction, $F(8,100) = 2.10, p < .05$.

Of particular interest were several significant univariate effects involving the dimension factor, including main effects of references to self, $F(1,53) = 27.60, p < .001$, listener, $F(1,53) = 43.82, p < .001$, landmarks, $F(1,53) = 9.84, p < .005$, and nonspecific reference objects, $F(1,53) = 24.72, p < .001$. Interestingly, the direction of these effects differed for the different types of reference objects.

| TABLE 3 |
| EXPERIMENT 1: MEAN PERCENT DIRECTIONS INCLUDING FRAMES OF REFERENCE AS A FUNCTION OF AGE AND DIMENSION |

<table>
<thead>
<tr>
<th>AGE GROUP/DIMENSION</th>
<th>FRAME OF REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self</td>
</tr>
<tr>
<td>4 years (n = 20):</td>
<td></td>
</tr>
<tr>
<td>Front-back</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>(16)</td>
</tr>
<tr>
<td>Left-right</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(3)</td>
</tr>
<tr>
<td>6 years (n = 20):</td>
<td></td>
</tr>
<tr>
<td>Front-back</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>(12)</td>
</tr>
<tr>
<td>Left-right</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
</tr>
<tr>
<td>8 years (n = 20):</td>
<td></td>
</tr>
<tr>
<td>Front-back</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>(11)</td>
</tr>
<tr>
<td>Left-right</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>(14)</td>
</tr>
</tbody>
</table>

NOTE.—Standard deviations are in parentheses.
objects. As Table 3 shows, proportional use of self and listener references by children of all ages was higher for directions about FB arrays than directions about LR arrays. There was a significant univariate age \times dimension interaction for references to the listener, $F(2,53) = 4.35, p < .05$. Post hoc analyses (Tukey's HSD, alpha = .05) showed that 4- and 6-year-olds used a greater proportion of listener references in their directions about the FB dimension than the LR dimension. In contrast, there was no difference in the percentage of listener references in the 8-year-olds' directions about the FB and LR dimensions. Table 3 reveals a similar trend for references to self, although the age \times dimension interaction was not significant, $F(2,53) = 2.37, p = .10$.

The data for references to landmarks contrast sharply with those for self and listener references. At each age, a higher proportion of landmarks were used in directions about LR arrays than those about FB arrays. Not surprisingly, there was also a significant main effect of condition, $F(1,53) = 4.17, p < .05$, with landmarks being used in a greater percentage of directions in the differentiated condition (15%) than in the undifferentiated condition (8%).

In summary, 4-year-olds performed moderately well with the FB dimension, but they were rarely able to accurately specify location for the LR dimension. Both 4- and 6-year-olds gave more effective directions for the FB arrays than the LR arrays. Eight-year-olds, however, performed comparably on both dimensions, with the exception of the LR four-cup linear array (array 3, see Table 1). It is unlikely that 8-year-olds' difficulty with array 3 was due solely to an increase (from two to four) in the number of cups, since the same increase did not disrupt their performance on the FB dimension for arrays 4 and 5. Nor does the additional requirement of a ME distinction completely account for this finding, since this was also a requirement for the FB four-cup linear array. Instead, the data suggest that LR relations were problematic even for the 8-year-olds, but that this was only evident when the task demands were increased (see Harris, 1972).

The patterns of reference-object use observed here suggest that the increasing competence of children with age reflects shifts in the strategies used for communicating about spatial location. In addition, the patterns of reference-object use differed for the FB and LR dimensions. Even when differentiating landmarks were available, 4- and 6-year-olds used references to persons to specify location in FB arrays. The correlations between effectiveness and use of person references for the FB dimension were quite high and statistically significant for both age groups (4-year-olds: $r = .81$; 6-year-olds: $r = .79, p < .01$), indicating that children successfully executed this person-based strategy. While 4-year-olds did not attempt to deal with LR arrays by switching to a landmark-based strategy, 6-year-olds did. Six-year-olds' performance with LR arrays benefited from the presence of distinctive landmarks. They constructed a greater number of effective directions for LR arrays when the landmarks were distinctive, and thus useful for specifying location, than when they were not distinctive. The correlation for 6-year-olds between effectiveness and use of landmarks for the LR dimension in the differentiated condition was quite high ($r = .71, p = .01$), indicating that they were successful in utilizing this landmark-based strategy. Increasing competence between the ages of 4 and 6 years for communicating about the LR dimension appears to be due to a shift in strategy and not to more effective use of landmarks in spatial directions. Unlike the younger children, 8-year-olds used a combination of person and landmark references in their directions about both FB and LR arrays. This older group was able to construct as many effective directions for the LR arrays when landmarks were distinctive as when they were not, suggesting that they were successful at using themselves and their listener as reference objects when communicating about the LR dimension.

The findings that 6-year-olds referred to the curtains more often and 8-year-olds used the tape more often in the differentiated than undifferentiated condition indicate that these age groups recognized the usefulness of distinctive, as opposed to nondistinctive, landmarks in describing spatial location. Four-year-olds' use of landmarks, on the other hand, was infrequent in both differentiation conditions. It may have been that the salience of the environmental cues in this experimental situation was insufficient to elicit their attention (see Acredolo, 1976; Acredolo & Evans, 1980). A follow-up experiment failed to provide convincing evidence for this hypothesis, however.\(^2\)

\(^2\) Well-known cartoon characters were added to the color-differentiated tape and curtains, each cartoon character being paired with a particular color (see Fig. 1). Planned comparisons showed that
Another result from Experiment 1 was that children of all ages referred to the listener in a relatively high proportion of their directions. Was the frequent use of the listener due to his or her proximity to the hiding location, or was use of the listener prompted in some other way by the communicative nature of this task? A second experiment in which the table was moved away from the listener explored the first possibility.

**Experiment 2**

**METHOD**

**Subjects**

Twenty 6-year-olds (mean age: 6-10; range: 6-3 to 7-7) and 20 8-year-olds (mean age: 8-11; range: 8-5 to 9-6) from a metropolitan parochial school participated, with equal numbers of girls and boys in each experimental condition.

**Design and Procedure**

The experimental room, procedure, coding, and analysis were the same as in Experiment 1. Children gave directions in the original undifferentiated condition, with the cup-array table located either directly in front of the listener (proximal listener condition) as in Experiment 1 or on the opposite side of the room, 27 inches (68.6 cm) in front of the subject's chair (distal listener condition). If the proximity of the listener to the cup array in Experiment 1 accounts for children's frequent use of listener references, then one would expect a lower proportion of listener references in the distal listener condition than in the proximal listener condition.

Coding reliability for eight (20%) of the subjects was 90% for the effectiveness variable and 93% for the listener reference-object variable.

**RESULTS AND DISCUSSION**

**Effectiveness**

A 2 (age) × 2 (condition: proximal vs. distal listener) × 2 (sex) ANOVA for effectiveness revealed a significant main effect of age, $F(1,32) = 23.90, p = .001$, and a marginally significant main effect of condition, $F(1,32) = 3.92, p = .056$. Eight-year-olds gave a greater percentage of effective directions than the 6-year-olds (75% and 37%, respectively), and subjects' performance was slightly better in the distal than in the proximal listener condition (63% and 48%, respectively).

**Use of Listener as Frame of Reference**

Reversing the relative distance of the child and the listener from the cup array did not result in a decrease in proportional use of the listener. In fact, a 2 (age) × 2 (proximal vs. distal listener condition) × 2 (sex) ANOVA on the mean percentage of directions including listener references revealed a significant main effect of condition, $F(1,32) = 6.59, p < .05$; MS error = 7.01, with a greater proportion of references to the listener in the distal listener condition than in the proximal listener condition (see Fig. 4). There was also a significant main effect of age, with 8-year-olds producing more listener references than 6-year-olds, $F(1,32) = 23.59, p = .001$.

Thus, the results of Experiment 2 do not support the hypothesis that the frequent use of the listener as a reference object in Experiment 1 was due to the listener's proximity to the cup array. Moving the listener farther from the cup array resulted in a higher, not a lower, proportion of references to the listener. In addition, children performed better when the cup array was close to them and far from the listener. What might account for these effects? The increase in effectiveness may have been due to the location of the hidden toy being easier to encode and remember when the cup array was closer because it could be seen with less effort. If this is true, the child may be able to devote more attention to effectively solving and coordinating other requirements of the task. In addition, children may have been aware that the listener might have some difficulty seeing the cups when the table was close to the child and consequently may have tried to make the listener's task easier by encoding the toy location in reference to the listener. Future studies that independently vary the distances of the listener and the child from the cup array may help to determine how the absolute distance of the listener (or child) from the cup array, as well as the relative distance of listener and child from the array, affects children's performance in this task.
General Discussion

The patterns that emerged in the types of reference objects children used to communicate spatial location and their varying successes in producing effective directions provide a new perspective on developmental changes in spatial frames of reference. Taken together, the results illustrate that (1) although children's overall performance improved with age, the rate of improvement differed for directions about the front-back and left-right dimensions, and (2) the frames of reference that children incorporated into their directions changed with age and differed for directions about the front-back and left-right dimensions. Four-year-olds gave effective directions for the front-back dimension about half of the time but hardly ever succeeded with the left-right dimension. Their success with the front-back dimension appears to reflect their use of themselves and their listener as reference objects in their directions. Use of landmarks for the front-back dimension was much lower in comparison. Not surprisingly, 4-year-olds almost never referred to themselves or their listener in their directions about the left-right dimension. However, they did not compensate for their apparent inability to use self or listener references by attempting to use distinctive landmarks. Nor did they use distinctive landmarks when they were made more salient (see n. 2).

Six-year-olds, on the other hand, constructed effective messages about the front-back dimension about three-quarters of the time and gave a comparable percentage of effective directions for the left-right dimension as 4-year-olds did for the front-back dimension. Six-year-olds' success with the front-back dimension appears to reflect a relatively high proportion of references to themselves and their listeners, along with a greater proportion of landmark references compared to 4-year-olds. Like the 4-year-olds, 6-year-olds rarely used themselves or their listener to specify location for the left-right dimension. However, they were able to compensate to some extent for their apparent difficulty in using the terms left and right by relying more heavily on the landmarks as markers for left and right. This switch from person references in directions about the front-back dimension to landmark references in directions about the left-right dimension helps explain why 6-year-olds did better than the 4-year-olds with the left-right dimension.

In general, the 8-year-olds performed equally well with front-back and left-right arrays, with the exception of the four-cup left-right linear array, as noted above. The percentage of effective directions by 8-year-olds for the left-right dimension was comparable to that of 6-year-olds for the front-back dimension. In contrast to the younger children, 8-year-olds referred to themselves and their listener to specify location in the left-right arrays by giving directions such as, "It's the last one on your right." This increase in references to themselves and their listener was accompanied by a decrease in the percentage of landmark references relative to the 6-year-olds.
These age changes in effectiveness for the front-back and left-right dimensions merge nicely with age changes in patterns of reference-object use. How should the age changes in use of reference objects observed here be interpreted? The developmental trends for use of reference objects differed from those reported in the spatial cognition literature (Acredolo, 1976, 1977; Acredolo et al., 1975; see Pick et al., 1979). First, there was no evidence for a developmental shift from the use of self- to other person- or landmark-based frames of reference. Instead, references to self increased with age. Second, there was not a shift from use of proximal to distal frames of reference; in fact, just the opposite occurred in this task. Six-year-olds referred more frequently to the distal curtains than to the proximal tape, and 8-year-olds referred more to the proximal tape than to the distal curtains.

The contrast between the present results and those reported in other spatial cognition studies illustrates the need for researchers to consider how task demands and developmental level mutually constrain reference-system use. Several task variables are likely to have played a role in our communication task. First, successful communication of location requires the child to provide unambiguous information to the listener. One aspect of this requirement is the need to specify unambiguously whatever reference objects one is attempting to use in a direction. In our task, saying “It’s the close one” or “It’s by the red” did not allow the listener to determine which reference object the child had in mind. The percentage of these nonspecific references decreased dramatically between 4 and 6 years and dropped slightly between 6 and 8 years. Nonspecific references also appeared much more frequently in directions about the left-right than the front-back dimension at all ages. These two findings indicate that children became increasingly able with age to provide unambiguous information to their listener.

More generally, the relatively high frequency of directions containing references to the listener suggests that children of all ages grasped the importance of helping the listener relate his or her position to that of the target location. The fact that the 4- and 6-year-olds referred to the listener about twice as often as they referred to themselves suggests that the listener was seen as more than just a salient landmark. Were this not the case, one would expect equal numbers of references to self and listener, since for half of the front-back trials the toy was located in a cup closer to the child than the listener, and for the other half the opposite was true. Hence, the higher proportion of references to the listener includes directions such as “It’s the farthest one from you.” Such statements indicate that children were able to communicate location from the listener’s perspective rather than merely marking the location as closer to themselves or their listener. The results of Experiment 2 suggest that the high percentage of references to the listener was not just a product of the listener being close to the table and hence a salient landmark, since references to the listener actually increased when the table was moved away from him or her. This is consistent with previous work indicating that, by 4 years of age, children are able to use their listener’s perspective in specifying whether an object is in front of or behind a wall dividing the child and the listener (deVilliers & deVilliers, 1974).

Second, children’s directions about the left-right dimension offer insight into how language abilities constrain children’s use of frames of reference. Children referred to themselves and their listener in the majority of their directions about the front-back dimension even when differentiated landmarks were present. This suggests that the low frequency of 4- and 6-year-olds’ references to themselves and their listener in directions about the left-right dimension was due to their inability to use left and right. In contrast, 8-year-olds referred to themselves and their listener relatively often for directions about both the front-back and left-right dimensions. This relatively late developmental shift toward using self and listener references for the left-right dimension is not surprising, given previous research documenting that children only begin using the terms left and right relationally around 7 or 8 years (Harris, 1972).

Finally, the ability to attend to and select relevant spatial information may also account for some of the developmental differences observed in our task. Children of different ages may have focused their attention on different kinds of environmental landmarks. Four-year-olds rarely used landmarks, perhaps because keeping track of the hiding location in relation to themselves, their listener, and the other cups occupied their full attentional capacity. Future work may determine whether 4-year-olds use landmarks if the task load is reduced, for example, by marking the target cup. The 8-year-olds’ relatively high proportion of references to the tape on the table indi-
cates that they also focused their attention on a rather narrow area. However, given the 6-year-olds’ frequent use of the distal curtains, this tendency of the oldest children to use proximal landmarks most likely reflects their appreciation of the listener’s perspective, rather than an inability to use distal landmarks. Other studies in which children’s allocation of visual attention is directly measured would provide empirical evidence for these hypothesized developmental changes in attention.

Task variables can cause children not to use a particular frame of reference for either of two reasons. In some cases, task demands may make it impossible for children to use a given frame of reference. For instance, 6-year-olds in the present study may have been unable to use a self- or other-based frame of reference for directions about left-right arrays. In other cases, such as 8-year-olds’ relatively frequent references to the tape, it seems reasonable to infer that the task led them to choose a proximal over a distal frame of reference. Future studies that directly compare reference system use in different spatial tasks would provide a more complete picture of the factors underlying developmental changes in the use of frames of reference.

It is worth noting that our task, with its requirement not to point, represents one of a variety of possible communication situations. When the target object is visible to both speaker and listener and is not surrounded by other objects, pointing is often all that is required to communicate the object’s location. However, when many objects are present (as was the case with the cup arrays), pointing must be supplemented with verbal information. Finally, in some instances the speaker and/or listener cannot see the target object while its location is being communicated. In this case pointing is of course not useful and, in addition, the speaker must remember the target location and imagine the listener’s perspective relative to that location. The present report examined children’s ability to give verbal directions when pointing is not useful and when it was not necessary to remember the target location.

Indicating where things are is an important, and not well understood, aspect of identifying or referring to objects (Miller & Johnson-Laird, 1976, p. 410). The experiments reported here provide an initial look at how children use location to verbally identify a target object. Many questions remain unanswered. What governs the choice of a particular reference object to specify another object’s location? Why does the choice of reference objects change with age? Studies that combine methods and theories from the fields of spatial cognition, referential communication, and language development may provide answers to these and other interesting questions about spatial reference.

References


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