

# The Early Development of Children's Communication about Nested Spatial Relations

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PLUMERT, JODIE M.; EWERT, KIMBERLY; and SPEAR, SARA J. *The Early Development of Children's Communication about Nested Spatial Relations*. CHILD DEVELOPMENT, 1995, 66, 959-969. This investigation examined how the nature of the spatial relation influences young children's ability to remember and communicate about nested landmarks. Of particular interest was whether young children are more likely to use a supporting than a proximal landmark to disambiguate identical landmarks (e.g., "it's in the basket *on* the table" vs. "it's in the basket *next to* the table"). 3- and 4-year-olds hid objects in a dollhouse and described their locations. Children had to disambiguate the target primary landmark by relating it to a supporting or proximal secondary landmark. Both age groups almost always provided the primary landmark, but 4-year-olds were more likely to provide the secondary landmark than were 3-year-olds. Moreover, children were more successful at providing supporting than proximal secondary landmarks. These results suggest that both referential communication skills and biases in coding location influence children's communication about nested landmarks.

Young children are often confronted with requests to describe the whereabouts of missing objects. Yet with the exception of studies on the acquisition of spatial terms (e.g., Bowerman, 1989; Clark, 1980; Johnston, 1984; Johnston & Slobin, 1979), little is known about the emergence of spatial communication skills or the factors that influence young children's ability to communicate successfully about object locations. In particular, surprisingly little research has been directed at young children's ability to communicate about nested spatial relations, or, in other words, spatial relations that hold between progressively larger landmarks and spatial regions. Because there are many potentially confusable locations in any given space, successfully remembering and communicating about where an object is often requires coding its location in relation to two or more nested landmarks. For example, references to nested landmarks in statements such as "the soda is in the *bag* by the *stove*" help the listener differentiate between the target bag and other identical bags in the room (Craton, Elicker, Plumert, & Pick, 1990). Encoding such nested spatial re-

lations is also important for distinguishing a particular bag from other identical bags should one want to find the soda later (Huttenlocher, Newcombe, & Sandberg, in press).

Although research on the topic is scarce, the available evidence suggests that children progress from describing a target object in relation to a single landmark, to describing a target object in relation to a nested series of landmarks and spatial regions (Craton et al., 1990; Plumert, Pick, Marks, Kintsch, & Wegesin, 1994). In a study of children's use of frames of reference in communication, Craton et al. (1990) asked 4-, 6-, and 8-year-olds to describe the location of a hidden toy under one of several identical cups arranged on a small table. Strips of colored tape on the table and colored curtains hanging in the doorways of the testing room were available as landmarks for distinguishing among the identical hiding locations. Thus, in order to describe the location of the hidden toy unambiguously, children had to code the object in relation to the target cup, and the target cup in relation to another

This research was supported in part by a University of Iowa Old Gold Summer Fellowship. The authors would like to thank Lisa Oakes for her helpful comments on earlier drafts of this paper, and the following preschools for their enthusiastic cooperation: Brookland Woods Child Care Center, Eadeschool, Kindercampus, Montessori School of Iowa City, and Rainbow Day Care Center. Portions of this paper were presented at the 1992 Conference on Human Development in Atlanta, GA, April 10-12, and at the 1993 Meeting of the Society for Research in Child Development in New Orleans, LA, March 25-28. Requests for reprints should be addressed to Jodie Plumert, Department of Psychology, 11 SSH East, University of Iowa, Iowa City, IA 52242.

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landmark. Although 6- and 8-year-olds differed in the types of landmarks they used in their communication, they had little difficulty relating the target cup to a landmark (e.g., "it's under the cup *next* to the red tape"). The 4-year-olds, however, had great difficulty using landmarks to distinguish the target cup from the other identical cups. Moreover, a follow-up study in which the landmarks were made more salient did not result in any significant gains in 4-year-olds' performance.

What accounts for young children's difficulty with communicating about nested spatial relations? One possibility is that young children do not fully take into account the needs of the listener. In short, when potentially confusable locations exist within a space, the child must recognize the need to provide additional spatial information that will help the listener distinguish between the target referent and other similar nonreferents. In the referential communication literature, this knowledge has been referred to as the "difference rule." A wealth of evidence exists showing that preschoolers lack an understanding that a message should describe differences between a referent and the objects with which it might be confused (Robinson, 1981; Sonnenschein & Whitehurst, 1984). Although nearly all of the research to date has focused on children's ability to identify objects on the basis of their appearance (e.g., size, shape, or color), the same rules of communication apply to identifying objects on the basis of their location relative to other objects in the environment. Therefore, one might expect that preschoolers would have similar sorts of difficulty with providing information to distinguish among identical locations.

A second factor that may influence young children's ability to communicate about nested spatial relations is the type of spatial relation that holds between nested landmarks. In the Craton et al. (1990) study, the only way to distinguish among the identical cups was to use the relation of *proximity* (e.g., "it's in the cup *by* the blue curtain"). Moreover, the cups on the table were spatially separated from the tape and curtain landmarks. Thus, even though English-speaking children are able to produce the spatial prepositions "by" and "next to" by 3 years of age (Clark, 1980; Johnston, 1984; Johnston & Slobin, 1979), they may have difficulty with using proximity relations to disambiguate object locations, particularly

when the target object and landmark are not in contact with one another.

One source of information about biases children may have in coding spatial relations is the order in which spatial terms are acquired. More specifically, children learning a wide variety of languages acquire terms such as "in" and "on" before terms such as "next to" (Clark, 1980; Dromi, 1979; Johnston, 1984; Johnston & Slobin, 1979; Washington & Naremore, 1978). As Clark points out, this order of acquisition may reflect in part the early conceptual underpinnings of linguistic knowledge (for an alternative view see Choi & Bowerman, 1991). Johnston (1984), for example, has shown that the order in which children grasp spatial terms mirrors their performance on related nonlinguistic tasks. Recent research also has shown that very young infants attend to information about support. For example, 4.5-month-old infants are surprised when an object remains suspended in midair with no apparent source of support (Needham & Baillargeon, 1993). By 8 months of age, infants use support relations in their means-ends behavior (Willats, 1990). Thus, 8-month-olds will pull on a cloth to retrieve an object that is placed on the cloth but out of reach. In language tasks, 2-year-olds show a strong preference for placing objects on or in other objects even when instructed to place the object in front of or behind the other object (Clark, 1973, 1980).

One question these findings about early spatial concepts raises is why might infants and young children grasp support relations before proximity relations. One possible reason is that support carries important functional meaning within the physical world. Specifically, when one object is on top of another object, the bottom object serves the function of supporting the top object. Even in cases in which the two surfaces are vertical, such as a picture hanging from a nail on a wall, the wall and the nail serve to support the picture. Support relations also have important consequences for how objects interact with one another. Most notably, objects fall when surfaces of support are removed. Equally important, however, is the fact that objects tend to move with supporting surfaces when those surfaces are moved. For example, if a plant is sitting on a table and the table is moved, the plant accompanies the table to the new location. The intimate ways in which objects involved in support relations interact may further serve to underscore the connection between such objects

for the young child and hence explain why this concept may retain a relatively privileged status even after other spatial concepts have been mastered.

A second reason why support relations may be easier for young children to learn than proximity relations concerns the specificity of each relation. In English, the meaning of the term "on" is usually all-or-none in nature, that is, an object can be either on or off another object. In contrast, proximity is largely relative in nature. Thus, whether one object is considered to be near another object often depends on how close other neighboring landmarks are. For example, if a book is 12 inches away from a coffee table and 24 inches away from a couch, it is likely that we would perceive the book as near the coffee table. If the coffee table is removed from the scene, however, we would be likely to think of the book as near the couch. Young children may be less certain about when one object is near another than when one object is on another object, and hence be less likely to code proximity than support relations within the environment.

The primary goal of the present investigation was to examine how the nature of the spatial relation influences young children's communication about nested landmarks. Of particular interest was whether young children are more likely to use a supporting than a proximal landmark to disambiguate identical objects for a listener (e.g., "the hat is in the basket *on* the table" vs. "the hat is in the basket *next to* the table"). The second goal of this investigation was to examine whether young children also are more likely to remember the location of an object when the object is supported by rather than proximal to a landmark. Although studies of young children's object retrieval have shown that their memory for the spatial relation between an object and a single landmark is very good (Cornell & Heth, 1983; DeLoache & Brown, 1983, 1984), no studies to date specifically have compared young children's memory for different types of spatial relations.

In this investigation, 3- and 4-year-olds helped an experimenter hide a miniature mouse at several locations in a dollhouse bedroom. After hiding the mouse, children were asked to describe where it was located. There were eight pairs of identical primary landmarks that served as hiding locations. The experimenter instructed children to hide the mouse at one location of the pair,

but the other location was always left empty. Thus, it was necessary for the child to relate the primary landmark to another, or secondary, landmark in order to distinguish clearly which hiding location they were referring to. The issue of how the spatial relation influences the likelihood that young children will provide a secondary landmark was examined by placing half of the target primary landmarks *on* the secondary landmarks, and the other half *next to* the secondary landmarks. After completing the communication task, children performed an object replacement task in which the experimenter removed the eight target primary landmarks from the dollhouse and then asked the children to put the landmarks back exactly where they were before. The issue of how young children's ability to remember object locations is influenced by the nature of the spatial relation was addressed by comparing children's success in replacing the objects involved in support relations with their success in replacing objects involved in proximity relations.

## Method

### Subjects

Subjects were 21 3-year-olds and 21 4-year-olds from predominantly middle- to upper-middle-class Caucasian families. The mean ages were 3-8 (range = 3-3 to 4-0) and 4-7 (range = 4-1 to 5-0). There were 10 males and 11 females in the 3-year-old group, and 10 males and 11 females in the 4-year-old group.

### Apparatus and Materials

A 22 × 12 × 12-inch model room designed to look like a child's bedroom was used as the experimental space (see Fig. 1). A miniature mouse served as the target hidden object, and a 4-inch-high troll served as the listener. A Plexiglas cover that could be raised and lowered over the front of the house was used to prevent children from pointing directly at locations or retrieving the mouse before they described its location. Within the room there were eight primary landmarks that served as hiding locations. Approximately 5 inches from each primary landmark was an identical object. Thus, in order to disambiguate the target primary landmark from its nontarget partner, children had to refer to another, or secondary landmark (e.g., "the mouse is under the *hat* next to the *bed*"). There were four pieces of furniture that served as secondary landmarks: a bed, table, chair, and bookshelf. Each of the four furniture items served as a

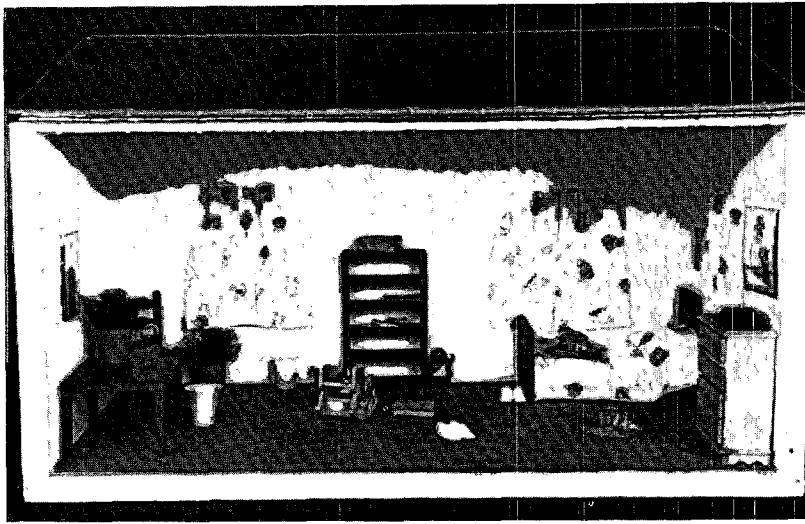


FIG. 1.—Model room used as experimental space

secondary landmark for two target primary landmarks. One of these landmarks was placed *on* the piece of furniture, and the other was placed *next to and touching* the furniture item. Therefore, all locations involved contact between the primary and secondary landmarks, but four involved the relation of support and four involved the relation of proximity (see Table 1). The secondary landmarks in the support relations all provided a horizontal surface of support. The primary landmarks involved in proximity relations were lateral to the secondary landmarks from the position of the viewer. Three primary landmarks were placed to the right of the secondary landmark, and one was placed to the left of the secondary landmark. The primary landmark that was placed on or next to each secondary landmark was counterbalanced across children. For example, either the spaceman was next to the bookshelf and the bag was on the bookshelf,

or the bag was next to the bookshelf and the spaceman was on the bookshelf. This was done to ensure that any differences in performance were due to the spatial relation rather than the specific primary and secondary landmarks involved in the spatial relation. The dollhouse was placed on a low table and the child was always seated directly in front of it. The experimenter sat on the child's right side.

*Design and Procedure*

Children were tested individually at their preschool or in the laboratory. During familiarization with the dollhouse, children were shown the troll figure and told that he lived in the house. They were instructed that they would be hiding a small mouse in the room while the troll was not looking, and that they would have to try to tell the troll where the mouse was hiding. Children then were familiarized with all of the objects and

TABLE 1  
CONFIGURATIONS OF PRIMARY AND SECONDARY LANDMARKS USED AS HIDING LOCATIONS

SUPPORT LOCATIONS		PROXIMITY LOCATIONS	
Primary Landmark	Secondary Landmark	Primary Landmark	Secondary Landmark
behind bear	on table	in trashcan	by table
in pail	on chair	behind plant	by chair
in bag	on bookshelf	behind spaceman	by bookshelf
under hat	on bed	in shoes	by bed

furniture in the dollhouse by being asked to name each item in a random order. If children could not name an item, the experimenter supplied the label and later questioned them about that item to make sure they remembered its name. Children first were given a practice trial in which they hid the mouse behind the nontarget bear and were asked to describe its location to the troll.

*Spatial communication task.*—There were eight test trials involving the eight target primary and secondary landmarks. The order in which children described the hiding locations was randomized across subjects. For each trial, the experimenter put the troll behind the dollhouse and then touched the hiding location with a pencil and instructed the child, “put the mouse right there.” For all locations, the mouse was completely hidden from view. After the mouse was hidden, the experimenter closed the cover and reminded the child not to point to the mouse’s location. Children were also instructed to either cross their arms or sit on their hands. The experimenter then brought the troll to the front of the dollhouse and asked the child to tell the troll where the mouse was hiding. As little delay as possible was imposed between hiding the mouse and describing its location to reduce the possibility that children would forget locations. If the child’s description was inadequate to specify the mouse’s location precisely, the experimenter would give a series of structured prompts to the child for more information. The first prompt was always, “can you tell the troll *more* about where that mouse is?” If the child provided only the primary landmark (e.g., “it’s behind the bear”), the experimenter followed up the first prompt with “can you tell the troll *where* the [primary landmark] is?” If the child’s directions were ineffective after these prompts, the experimenter would open the room and ask the child to retrieve the mouse. All directions were audiotaped.

*Object replacement task.*—Children also performed a second task of replacing the primary landmarks that had served as hiding locations in the communication task. The child was instructed to go behind the dollhouse and face the opposite direction. While the child was facing away, the experimenter removed the eight target primary landmarks from the dollhouse and placed them in a cluster in front of the dollhouse. The child was then called back and asked to put the objects back exactly where they were before.

Only the primary landmarks that served as hiding locations in the communication task were used to ensure that children had previously experienced equal opportunity to attend to the objects in question. Again, four of these locations involved the relation of support and the other four involved the relation of proximity. After the session was finished, the experimenter coded the accuracy of the child’s placements of the objects. Six children’s placements of the objects also were videotaped for reliability coding.

#### *Coding*

*Spatial communication task.*—Each subject’s directions were transcribed verbatim from audiocassette tape recordings. All directions were coded for presence or absence of the targeted information and analyzed as percentages. Locations for which children forgot where the mouse was hiding were not included in percentage scores. Such errors were infrequent, however, and did not differ according to age,  $F(1, 40) = 0.00$ , N.S. The mean number of forgetting errors made by 3- and 4-year-olds was .10 and .10, respectively.

The following aspects of children’s communication were coded: (1) primary landmark references, (2) secondary landmark references, (3) primary landmarks mentioned first, (4) primary and secondary landmarks mentioned in a single utterance, (5) support terms, and (6) proximity terms. With the exception of children’s production of support and proximity terms, only utterances produced spontaneously and in response to the first prompt (i.e., “can you tell the troll more about where the mouse is hiding?”) were coded. A *primary landmark reference* was coded as present when children mentioned or described the object with which the mouse was hidden (e.g., “the mouse is in the *bag*” or “the mouse is in the *brown paper thing*”). A *secondary landmark reference* was coded as present when children mentioned or described the object with which the primary landmark was placed (e.g., “next to the *bookcase*” or “next to the *book thing*”). Although children sometimes referred to the primary and secondary landmarks in a single description, the two were often produced separately. For example, it was not uncommon for children to give the primary landmark spontaneously, and to provide the secondary landmark in response to a prompt. Children were given credit for a secondary landmark reference in either case. A primary landmark was coded as mentioned first when children mentioned only

the primary landmark or mentioned the primary landmark before the secondary landmark. A primary and secondary landmark were coded as present in a single utterance if children mentioned both landmarks with no intervening prompting from the experimenter.

A support term was coded as correct when children used the word(s) "on" or "on top of." A proximity term was coded as correct when children used the word(s) "by," "next to," "beside," "near," or "at." Coding of children's production of support and proximity terms was based on the information conveyed after all prompts were given. Including children's responses to specific prompts made it possible to assess more accurately their linguistic performance because one could be fairly certain that children did not know the correct secondary landmark or spatial term if they did not provide a secondary landmark or use a correct spatial term in response to the question, "can you tell the troll where the [primary landmark] is?"

Intercoder reliabilities were calculated on six randomly selected protocols using exact percent agreement. Reliabilities for primary landmarks mentioned first, primary landmarks mentioned, secondary landmarks mentioned, primary and secondary landmarks mentioned in single utterances, proximity terms, and support terms were 100%, 95%, 100%, 100%, 100%, and 94%, respectively.

*Object replacement task.*—Primary landmark replacements were coded as correct or incorrect and analyzed as percentages. A support replacement was coded as correct when children placed the object on the correct landmark, and a proximity replacement was coded as correct when children placed the object closer to the correct landmark than to any other nearby object. Three types of errors also were coded: (1) placing the object equally close or closer to a neighboring object than to the correct landmark; (2) placing the object near a non-neighboring object; and (3) placing the object on top of another object. Reliability estimates for correct versus incorrect replacements and error type were calculated using exact percent agreement from videotapes of six subjects' landmark placements. Reliability for all measures was 100%.

## Results

The results for the spatial communication and object replacement tasks are re-

ported below in two separate sections. Analyses of references to the primary landmark focused on how often the two age groups mentioned the primary landmark and whether they mentioned the primary landmark before the secondary landmark. Analyses of references to secondary landmarks focused on whether children communicated more successfully about supporting than proximal secondary landmarks and whether linguistic problems accounted for the pattern of secondary landmark references. Finally, the object replacement analyses focused on whether children more accurately replaced primary landmarks involved in support than in proximity relations and on the types of proximity relation errors. Analyses of primary and secondary landmark reference scores and landmark replacement scores first were analyzed with gender as a factor. None of these analyses revealed significant main effects of gender or interactions of gender with other factors ( $\alpha = .05$ ). Therefore, males and females were pooled in all subsequent analyses.

### SPATIAL COMMUNICATION TASK

#### *References to Primary Landmarks*

The major question about the primary landmark was whether it held special status in children's descriptions about the location of the mouse. In other words, did children perceive the primary landmark as most closely related to the location of the hidden mouse? The first analysis compared the percentage of locations in which 3- and 4-year-olds mentioned the primary landmark first. Scores were based on the number of locations in which the primary landmark was the first landmark mentioned divided by the total number of locations. Inspection of the means indicated that 3- and 4-year-olds mentioned the primary landmark first in 88% and 93% of their descriptions, respectively. A one-way ANOVA revealed no significant difference between the two age groups,  $F(1, 40) = 1.62, p > .05$ . The fact that children of both ages virtually always referred to the primary landmark first strongly supports the idea that children's notions of the whereabouts of the mouse were closely tied to the primary landmark.

The second analysis compared the frequency with which 3- and 4-year-olds referred to the primary landmark in their descriptions. Scores were based on the number of locations in which children referred to the primary landmark divided by the total number of locations. Three- and 4-year-olds'

scores for primary landmark references were compared in a one-way ANOVA. Although references to primary landmarks were very high in both age groups, 4-year-olds ( $M = .98$ ) mentioned the primary landmark significantly more often than did the 3-year-olds ( $M = .89$ ),  $F(1, 40) = 5.98$ ,  $p < .05$ .

#### References to Secondary Landmarks

The central issue concerning use of secondary landmarks was whether children were more likely to refer to supporting than to proximal secondary landmarks. Two analyses were used to address this issue. The first compared whether children were more likely to mention supporting than proximal secondary landmarks. Children received two scores: one that represented the number of supporting secondary landmarks mentioned divided by the total number of support locations, and one that represented the number of proximal secondary landmarks mentioned divided by the total number of proximity locations. Supporting and proximal secondary landmark scores were entered into an age (3 years vs. 4 years)  $\times$  spatial relation (proximity vs. support) repeated-measures ANOVA with the first factor as a between-subjects variable and the second as a within-subjects variable. This analysis yielded a significant effect of age,  $F(1, 40) = 31.70$ ,  $p < .001$ , indicating that 4-year-olds ( $M = .69$ ) were more likely than 3-year-olds ( $M = .27$ ) to mention a secondary landmark. Consistent with our expectations, this analysis also showed that references to supporting secondary landmarks ( $M = .58$ ) were significantly higher than those to proximal secondary landmarks ( $M = .38$ ),  $F(1, 40) = 14.82$ ,  $p < .001$ .<sup>1</sup>

The second analysis compared whether children were more likely to mention both the primary and the secondary landmark in a single utterance when the primary landmark was supported by rather than proximal to the secondary landmark. For example, were children more likely to say, "the mouse is *in* the trashcan *on* the table" than "the mouse is *in* the trashcan *by* the table?" Scores were calculated by dividing the number of support (proximity) locations in which they referred to the primary and secondary landmarks in a single utterance by the total

number of support (proximity) locations. Compound utterance scores for support and proximity locations were entered into an age (3 years vs. 4 years)  $\times$  spatial relation (support vs. proximity) repeated-measures ANOVA with the first factor as a between-subjects variable and the second as a within-subjects variable. This analysis also yielded a significant effect of age,  $F(1, 40) = 20.51$ ,  $p < .001$ , indicating that 4-year-olds ( $M = .35$ ) were more likely to mention both landmarks in a single utterance than were 3-year-olds ( $M = .06$ ). More importantly, however, children were more likely to mention both landmarks in a single utterance when the primary landmark was supported by ( $M = .25$ ) rather than proximal to ( $M = .15$ ) the secondary landmark,  $F(1, 40) = 4.88$ ,  $p < .05$ .

#### Production of Spatial Terms

One question that immediately comes to mind is whether children's difficulty with proximity relations was due to a problem with mapping support and proximity terms onto the correct conceptual referents. This issue was addressed in two ways. The first was to compare children's accuracy in producing spatial terms for proximity and support. Because scores for secondary landmarks were based only on whether children mentioned the secondary landmark, it is possible that the spatial term was used incorrectly or omitted altogether in children's references to the secondary landmark. If children were more likely to make errors with proximity than support terms, one might conclude that the difference between children's use of supporting and proximal secondary landmarks was due to difficulty with mapping proximity terms onto proximity relations rather than a bias in coding location. Scores for proximity and support terms were calculated by dividing the number of support (proximity) terms used correctly by the number of support (proximity) secondary landmarks mentioned after all prompts were given.

Scores were entered into an age (3 years vs. 4 years)  $\times$  spatial term (support vs. proximity) repeated-measures ANOVA with the first factor as a between-subjects variable and the second as a within-subjects variable.

<sup>1</sup> In fact, additional analyses in which children's responses to the specific prompt (e.g., "can you tell the troll where the bear is?") were included in their scores for supporting and proximal secondary landmarks yielded the same pattern of results. Thus, even when asked a direct question about the location of the primary landmark, both 3- and 4-year-olds were more likely to provide a supporting than a proximal secondary landmark.

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Five 3-year-olds and two 4-year-olds were excluded from this analysis because they did not mention any supporting and/or proximal secondary landmarks. (Three of the 3-year-olds and the two 4-year-olds failed to mention any proximal landmarks, and the other two 3-year-olds failed to mention any supporting or proximal landmarks.) Thus, data from 16 3-year-olds and 19 4-year-olds were included in the analysis. This analysis revealed no significant difference between children's support ( $M = .83$ ) and proximity ( $M = .80$ ) term scores,  $F(1, 33) = .16$ , N.S. However, the difference between 3-year-olds' ( $M = .72$ ) and 4-year-olds' ( $M = .89$ ) scores approached significance,  $F(1, 33) = 4.12$ ,  $p = .05$ .

The results of the previous analysis suggest that the difference between children's use of supporting and proximal secondary landmarks was not due to a difficulty with mapping proximity terms. However, it is possible that children who never provided proximal secondary landmarks or who always used proximity terms incorrectly were the primary contributors to the differences in supporting and proximal secondary landmark group means. As a conservative test of this possibility, supporting and proximal secondary landmark scores were compared in an analysis that excluded the children who always used proximity terms incorrectly or who failed to provide any proximal secondary landmarks. Nine 3-year-olds and three 4-year-olds met these criteria. Therefore, the analysis was carried out on the remaining 12 3-year-olds and 18 4-year-olds. As before, supporting and proximal secondary landmark scores were entered into an age (3 years vs. 4 years)  $\times$  spatial relation (support vs. proximity) repeated-measures ANOVA. As before, this analysis yielded significant effects of spatial relation,  $F(1, 28) = 8.92$ ,  $p < .01$ , and age,  $F(1, 33) = 15.96$ ,  $p < .001$ . The fact that an effect for spatial relation was found even when children whose production of proximity terms was nonexistent or always incorrect were excluded further counters the argument that the differences between supporting and proximal secondary landmarks were due to a mapping problem.

Although excluding children who had obvious problems with proximity terms did not change the pattern of results, it is possible that children who had relatively more difficulty producing proximity terms might also be less likely to mention proximal secondary landmarks. This was examined by

correlating 3- and 4-year-olds' proximity term scores with their proximal secondary landmark scores. Again, children who failed to mention any proximal secondary landmarks were excluded from this analysis, resulting in a total of 16 3-year-olds and 19 4-year-olds. The correlations for 3- and 4-year-olds were  $r = .04$ , N.S., and  $r = .28$ , N.S., respectively.

### OBJECT REPLACEMENT TASK

The central question about children's performance on the landmark replacement task was whether children were more likely to replace correctly primary landmarks *on* than *by* secondary landmarks. Children received a score for replacement of the primary landmarks involving support relations, and a score for replacement of the primary landmarks involving proximity relations. These scores were calculated by dividing the number of correct support (proximity) replacements by the total number of support (proximity) locations. Scores were entered into an age (3 years vs. 4 years)  $\times$  spatial relation (proximity vs. support) repeated-measures ANOVA with the first factor as a between-subjects factor and the second as a within-subjects factor. This yielded a significant main effect of age,  $F(1, 40) = 9.83$ ,  $p < .01$ , indicating that 4-year-olds ( $M = .92$ ) replaced landmarks correctly significantly more often than did 3-year-olds ( $M = .77$ ). Moreover, there was a significant effect of spatial relation,  $F(1, 40) = 22.66$ ,  $p < .001$ . Children correctly replaced objects involving support relations 93% of the time, but correctly replaced those involving proximity relations only 76% of the time.

Errors also were analyzed to explore possible factors underlying poorer performance on proximity relations. Because only seven 4-year-olds made errors on proximity locations, only the 3-year-olds' proximity errors were analyzed. Three 3-year-olds made no errors on proximity relations, and therefore only data from the remaining 18 3-year-olds were entered into the analysis. Scores were calculated by dividing the number of each type of error by the total number of proximity errors. The majority of errors were of two types: placing the object near a neighboring object ( $M = .57$ ), and placing the object near a non-neighboring object ( $M = .35$ ). Scores for these two types of errors were entered into a one-way repeated-measures ANOVA. This analysis yielded no significant difference between the two error types,  $F(1, 17) = 1.11$ ,  $p > .05$ , suggesting



that 3-year-olds were equally likely to confuse landmarks that were nearby one another as those that were in different areas of the dollhouse.

## Discussion

When asked a question about the location of an object, young children clearly understood that they should provide the landmark with which the object was positioned. Thus, nearly all of 3-year-olds' directions contained a reference to the primary landmark. Moreover, both age groups almost always mentioned the primary landmark before the secondary landmark. References to secondary landmarks, however, were dependent both on age and on the type of spatial relation that had to be expressed. Specifically, 4-year-olds were more likely to mention a secondary landmark than were 3-year-olds, and children of both ages were more likely to mention the secondary landmark when it provided a horizontal surface of support for the primary landmark than when it was proximal to the primary landmark. Moreover, children accurately replaced a greater percentage of primary landmarks involving support than proximity relations.

What accounts for the finding that 3-year-olds were much less likely to use a secondary landmark to differentiate the target and nontarget primary landmarks than were 4-year-olds? On a general level, there may be some developmental differences in young children's verbal fluency. This argument is supported by the finding that there also were developmental differences in children's references to the primary landmark. This difference was quite small (i.e., 9%), however, relative to the difference between 3- and 4-year-olds' references to the secondary landmark (i.e., 42%). This suggests that there are other factors beyond verbal fluency that account for developmental differences in references to secondary landmarks.

One possible explanation for the developmental difference in references to secondary landmarks is that the 3-year-olds did not notice that there were identical primary landmarks in the dollhouse. This seems unlikely, however, because the pairs of primary landmarks were purposefully positioned near each other so that the nontarget member of the pair would be clearly visible when children hid the mouse at the target primary landmark. Another possibility is that the younger children had difficulty disentangling their own knowledge of the mouse's

location with that of the listener. Although it would be an exaggeration to suggest that young children never take into account the knowledge of the listener (e.g., Maratsos, 1973), young children's ability to assess accurately what the listener knows shows considerable development over the preschool years (e.g., Perner & Leeham, 1986). This explanation is also consistent with recent research showing that 3-year-olds begin searching for an object equally quickly after an ambiguous or nonambiguous description, but 4-year-olds begin their search more slowly when the description is ambiguous than when it is nonambiguous (Plumert, 1995). Thus, even when 3-year-olds are on the receiving end of someone else's spatial descriptions, they are less sensitive than older children to referential ambiguity.

Another possible reason why younger children were less likely to differentiate the pairs of identical primary landmarks for the listener is that they did not know how to do so. In particular, younger children may have difficulty using location as a means of identifying objects. Younger children may find it easier to identify objects on the basis of properties intrinsic to the object (e.g., shape, color, texture) than on the basis of relational properties such as location. In the present investigation, referring to the relation between the primary landmark and the secondary landmark was the only possible means of disambiguating the pairs of primary landmarks. Further research comparing young children's ability to use different sources of information to disambiguate referents may shed light on developmental changes in young children's referential communication skills.

The fact that children were more successful at communicating about nested spatial relations involving support than proximity and were more successful at remembering object positions involving support than proximity clearly shows that the nature of the spatial relation influences children's coding of location. The major question this raises is, Why were children more successful with support than with proximity relations? First, it is important to note that even when children who never provided any proximal secondary landmarks or who always used proximity terms incorrectly were excluded from the analyses, the difference between support and proximity remained. Thus, it seems unlikely that children's omission of proximal secondary landmarks was due to a

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problem with mapping proximity terms onto the correct conceptual referent.

Another possible reason why children were more likely to relate primary landmarks to supporting than to proximal landmarks is that furniture typically serves a support function. As a result, children may be more familiar with thinking about furniture landmarks in terms of the relation of support than proximity. This explanation seems unlikely, however, because many of the furniture landmarks supported atypical primary landmarks (e.g., trashcan on the table, plant on the chair, bag on top of the bookcase). Thus, the items that the furniture supported in this experiment very likely violated children's expectations about the kinds of objects particular types of furniture usually support. Future studies that vary the typicality of the pairings of primary and secondary landmarks, however, may provide further information about how children's semantic knowledge interacts with their coding of location. For example, young children may be more likely to say, "the honey is in a jar by the bear" than "the honey is in a jar by the chair."

Another explanation of children's differential success in remembering and communicating about support versus proximity relations is that they perceived supporting landmarks as more salient and meaningful than proximal landmarks. More specifically, as young children's notions of where things are broaden beyond the immediate landmarks with which objects are positioned, they may first attend to secondary landmarks that serve meaningful functions such as support. With development, children presumably attend to a broader range of nested spatial relations and hence are more flexible in their coding of spatial location. Thus, when only proximal landmarks are available for disambiguating locations as in the Craton et al. (1990) study, older children have less difficulty making use of them than do younger children. Notwithstanding, these hypothesized early biases seem not to disappear with age; rather, they take on different forms. Recent work has shown that the order in which adults convey landmarks in their spatial descriptions is also influenced by the nature of the spatial relations involved (Plumert, Carswell, DeVet, & Ihrig, in press). For example, when describing the location of an object placed on a table by a pot, adults virtually always say, "it's *on* the table *by* the pot." If the object is placed on the pot, however, adults say, "it's *on* the table

*on* the pot" only about half of the time. The other half of the time, adults reverse the order of the two landmarks (i.e., "it's *on* the pot *on* the table"). Moreover, adults are more likely to omit reference to the pot altogether when the target object is next to rather than on the pot. These two findings concerning adults' ordering and omission of landmarks suggest that support relations retain their privileged status throughout adulthood.

It is important to point out, however, that the biases children and adults exhibit in their coding of spatial relations may have linguistic as well as conceptual origins. Although there are many uniformities across languages in the meanings expressed by spatial terms (Johnston & Slobin, 1979), spatial terms also differ in important ways across languages (Bowerman, 1989). Some languages make finer distinctions for spatial relations (e.g., "on") and some languages classify spatial relations using entirely different criteria (e.g., body-part metaphors). This suggests that linguistic constraints may also play an important role in biases children and adults exhibit in the coding of location. For example, English speakers may avoid using proximity to code object locations because the English language does not have clear rules about how close two objects must be in order to be classified as "by" one another. Hence, children may learn at an early age that proximity relations are less informative than other kinds of spatial relations such as support. Speakers of languages that make clear-cut proximity distinctions (e.g., requiring contact) may use proximity more readily in coding object locations. Further cross-cultural research may pinpoint similarities and dissimilarities in the biases that speakers of different languages exhibit in coding spatial location, and hence shed light on how conceptual and linguistic factors jointly constrain the ways in which children and adults remember and communicate about object locations.

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