Three experiments investigated 3- to 5-year-olds' ability to detect ambiguity in descriptions of location. In Experiments 1 and 2, children received ambiguous (e.g., “it's in one of the bags”) and nonambiguous (e.g., “it's in the bag by the chair”) descriptions. Four- and 5-year-olds' search latencies were longer for ambiguous than for nonambiguous descriptions, but 3-year-olds' latencies were longer for nonambiguous than for ambiguous descriptions. Experiment 3 revealed no difference in 3-year-olds' search latencies for ambiguous and nonambiguous descriptions when amount of spatial information in directions was equated. Five-year-olds' latencies again were longer for ambiguous than for nonambiguous descriptions. Discussion focuses on possible developmental factors contributing to changes in children's ability to detect spatial ambiguity.

The development of children's ability to communicate about location offers a unique vantage point for studying the intersection of language and cognitive abilities. In years past, interest in the juncture between young children's emerging cognitive and language abilities stimulated a great deal of research on the acquisition of spatial terms (e.g., Bowerman, 1989; Clark, 1980; Johnston, 1984; Johnston & Slobin, 1979). This level of analysis typically focuses on the spatial relation between a target object and a single landmark (e.g., “The newspaper is on the chair”). These studies have yielded important information about the acquisition of spatial terms both within and across languages. Only recently, however, have researchers begun to focus on how children communicate about the spatial relations among several landmarks (Craton, Elicker, Plumert, & Pick, 1990; Gauvain & Rogoff, 1989; Plumert, Ewert, & Spear, 1995; Plumert & Nichols-Whitehead, 1996; Plumert, Pick, Marks, Kintsch, & Wegesin, 1994). Because the environment is filled with many potentially confusable locations, speakers...
often find it necessary to refer to the spatial relations among two or more landmarks. For example, if there are several chairs in a room, one might distinguish the target chair from the other chairs by saying, “The newspaper is on the chair next to the couch.” As this example illustrates, spatial ambiguity poses a fundamental problem for communicating about location. Therefore, in order to act as effective speakers and listeners, children must learn how to detect and resolve spatial ambiguity. At present, most of what we know about the development of spatial communication focuses on children’s ability to produce unambiguous spatial messages (Craton et al., 1990; Plumert et al., 1995; Plumert et al., 1994). Far less is known about developmental changes in children’s ability to detect ambiguity in spatial messages.

Recent investigations of children’s spatial communication have shown that young children often give ambiguous spatial information to their listeners (Craton et al., 1990; Plumert et al., 1995). That is, young children often do not adequately distinguish a target location from other potentially confusable locations. In these studies, children typically help an experimenter hide a toy in or under one of several identical primary landmarks and then describe where the toy is to a listener. Therefore, it is necessary for children to relate the target primary landmark to another, or secondary, landmark in order to clearly distinguish which hiding location they are referring to (e.g., “It’s under the hat on the table”). Using this methodology, Craton et al. (1990) found that 6- and 8-year-olds were more likely than 4-year-olds to disambiguate the target primary landmark by relating it to a secondary landmark. In a similar study, Plumert et al. (1995) asked 3- and 4-year-olds to help an experimenter hide a miniature mouse in a one-room dollhouse and then describe its location to a small doll figure. Both 3- and 4-year-olds almost always referred to the target primary landmark (e.g., “It’s in the bag”), but 4-year-olds were more likely than 3-year-olds to disambiguate the small landmark by referring to the secondary furniture landmark (e.g., “It’s in the bag on the bookshelf”). Together, these results suggest that there are developmental changes between the ages of 3 and 6 years in children’s ability to communicate clearly about location.

What might explain these developmental differences in children’s spatial communication skills? One explanation of younger children’s performance in spatial communication tasks is that they have difficulty recognizing spatial ambiguity. That is, young children may not understand what constitutes an ambiguous location for a listener. If so, one might expect that young children would have difficulty knowing when they need to provide disambiguating spatial information to the listener. An alternative explanation for why young children are less likely than older children to disambiguate locations is that they do not know how to do so. That is, younger children may recognize spatial ambiguity, but have difficulty using the spatial rela-
tion between the target primary landmark and the secondary landmark as a means of disambiguating locations.

Distinguishing among these alternative explanations requires understanding whether young children can recognize spatial ambiguity. How might one evaluate young children's ability to recognize spatial ambiguity? One approach is to examine whether young children distinguish between ambiguous and nonambiguous descriptions when they are on the receiving end of spatial messages. At present, however, nothing is known about developmental changes in how children respond to ambiguity in spatial messages prior to middle childhood. Investigations of older children's comprehension of spatial messages suggests that there is continued improvement between middle childhood and adulthood in the ability to engage in sustained monitoring of referential ambiguity (Flavell, Green, & Flavell, 1985). Specifically, Flavell et al. (1985) found that when information given in the first part of a direction was ambiguous, 11-year-olds and adults were more likely than 7-year-olds to use information given in the second part of the direction to clear up the earlier ambiguity. The authors suggested that the younger children understood that the first direction was ambiguous, but did not appreciate the need to resolve the ambiguity because they were lulled into a false sense of certainty by the clarity and ease of execution of the second direction.

What kinds of developmental transitions might occur prior to middle childhood in how young children respond to spatial ambiguity? Although little is known about young children's comprehension of spatial directions, studies of children's comprehension-monitoring skills in other domains suggest that preschoolers are able to distinguish nonverbally between ambiguous and unambiguous messages, but only older children are able to indicate verbally when a message is ambiguous (Asher, 1976; Bearison & Levey, 1977; Markman, 1977; Patterson, Cosgrove, & O'Brien, 1980; Robinson & Robinson, 1976; Sonnenschein & Whitehurst, 1984). Bearison and Levey (1977), for example, found that 5-year-olds took longer to respond to ambiguous than to unambiguous questions. In their verbal evaluations of the two types of questions, however, 5-year-olds rarely judged questions containing pronouns without specified referents as ambiguous. These results suggest that although young children are able to detect ambiguity at some level, they may not have much awareness about their own level of comprehension (Patterson et al., 1980). That is, longer response latencies may reflect young children's uncertainty about the message, but they may not understand the implications of uncertainty for evaluating the ambiguity of the message.

As a first step in understanding developmental changes in children's comprehension of spatial messages, the investigation presented here investigated the early emergence of children's ability to nonverbally distinguish between
ambiguous and nonambiguous descriptions of location. The apparatus and materials were similar to those used by Plumert et al. (1995). Instead of describing how to find the hidden mouse, however, children searched for the mouse on the basis of the experimenter's descriptions. In the first two experiments, the experimenter hid the mouse at one of two identical locations (e.g., two red pots), and then gave children either an ambiguous description ("it's in one of the pots") or a nonambiguous description ("it's in the pot next to the piano"). Children were instructed to try to find the mouse on the first try and to ask questions if they were not sure about where the mouse was hiding. The primary measure was search latency, defined as the length of time that elapsed between the end of the experimenter's description and when children searched at the first place or asked a question about the location of the object. The logic behind this measure was that if children can detect ambiguity, then their search latencies should be greater for ambiguous trials than for nonambiguous trials. In other words, children should hesitate longer to initiate a search when given an ambiguous than a nonambiguous description.

On the basis of previous research on children's spatial communication and comprehension monitoring, it was expected that by age 4 to 5, children would detect spatial ambiguity and hence hesitate longer to search in response to ambiguous than to nonambiguous descriptions. Given that 3-year-olds almost always produce ambiguous directions (Plumert et al., 1995), one might expect that they also would not detect ambiguous descriptions and therefore their search latencies would not be related to spatial ambiguity. On the other hand, 3-year-olds' ability to produce unambiguous spatial descriptions might lag behind their ability to detect ambiguous spatial descriptions. In this case, 3-year-olds would show the same pattern of search latencies as would the older children.

**EXPERIMENT 1**

**Method**

*Participants.* Twelve 3-year-olds, twelve 4-year-olds, and twelve 5-year-olds from predominantly middle- to upper middle-class Caucasian families participated in the study. The mean ages were 3 years, 9 months (range = 3 years, 4 months–4 years, 0 months), 4 years, 8 months (range = 4 years, 3 months–5 years, 0 months), and 5 years, 7 months (range = 5 years, 3 months–5 years, 11 months). There were 5 boys and 7 girls in the 3-year-old group, 5 boys and 7 girls in the 4-year-old group, and 6 boys and 6 girls in the 5-year-old group. Children were recruited from an existing child subject registry. Parents first received a letter describing the study and later received a follow-up phone call asking if they and their child would like to participate.
Apparatus and Materials. A 28 in. wide × 16 in. deep × 12 in. high (71 × 41 × 30 cm) dollhouse served as the experimental space (see Figure 1). Within the dollhouse were eight pairs of identical objects that served as small landmarks and eight furniture items that served as large landmarks. The small landmarks included pails, shoes, lego people, plants, trashcans, paper bags, teddy bears, and hats. The large landmarks included a bookshelf, standing lamp, couch, desk, table, piano, TV, and chair. The small landmarks were randomly paired with the large landmarks with the constraint that both members of each pair had to be placed next to adjacent large landmarks. For example, if one pail was located next to the chair, the other pail was located next to the TV across from the chair. The purpose of this manipulation was to ensure that both identical landmarks were easily within view of one another. A miniature mouse served as the target hidden object on all trials. Children's searches were videotaped via a Panasonic camcorder positioned above the dollhouse. 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 left side.

Design and Procedure. Children were tested individually in the laboratory. They first were familiarized with all of the objects and furniture in the dollhouse by being asked to name each item in a random order. The experimenter pointed out the two members of each pair of identical primary

Figure 1. Dollhouse used as experimental space.
landmarks together to ensure that the children noticed both of them. That is, after the child named one member of the pair, the experimenter would point to the other member and say, "See, there's another one just like it right here." 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. After familiarization, all children participated in a communication task in which they hid the mouse at a small landmark (e.g., in one of the pails) and then described where the mouse was hiding to a small doll figure. Children completed eight trials involving one member of each pair of identical small landmarks.

After the communication task, the experimenter informed the children that they would be playing another game in which the experimenter would hide the mouse and then tell them where to look for it. The experimenter then sent children behind the dollhouse so that they could not see where he or she hid the mouse. After hiding the mouse the first time, the experimenter called the children back in front of the dollhouse and gave them the following instructions: "OK, I'm going to tell you where the mouse is hiding. I want you to try to find the mouse on the first try, so if you're not sure where to look, you can ask me questions about where the mouse is. So remember, I'll tell you where to look, but you can ask me questions if you're not sure about where the mouse is hiding." The experimenter then gave children either an ambiguous or a nonambiguous description of the location. Ambiguous descriptions did not differentiate between the identical small landmarks (e.g., "the mouse is hiding under one of the hats"). Nonambiguous descriptions differentiated the identical landmarks by relating the small landmark to the large landmark immediately next to it (e.g., "The mouse is hiding under the hat next to the couch").

There were eight test trials involving the eight pairs of identical small landmarks. Half of the trials involved ambiguous and half involved nonambiguous descriptions. Children periodically were reminded to try to find the mouse on the first try and to ask questions if they were not sure where the mouse was hiding. To ensure that there were no reliable cues to the location of the mouse on the ambiguous description trials, the member of each pair of small landmarks that served as the target location was randomized across the children. The order of ambiguous and nonambiguous descriptions and the order of hiding locations also were randomized across the children.

Measures. Children's search latencies were used to assess whether they differentiated ambiguous and nonambiguous descriptions. Children received a latency score for ambiguous descriptions and a latency score for nonambiguous descriptions. The two scores were based on the average amount of time taken to search for the mouse in response to each of the two types of descriptions. Latencies represented the time interval from the point
at which the experimenter finished giving the description, to the point at which children touched the first object they searched or asked a question about the location. A question was coded as present when children directly asked for more information about the location. This included statements such as, “Which one is it?” and “Is it the hat next to the couch?” A question also was coded as present if the child pointed to an object and said, “Is it this one?” without picking up the object to look. Questions were uncommon, however, occurring in only 8% of ambiguous trials. Two coders coded the latencies from videotapes for the entire set of participants. Coders pressed keys on a Macintosh IIfx computer to start and stop a timing program that recorded the latencies. Pearson correlations were used to calculate reliability on six randomly selected children’s search latencies. These correlations represented the degree of correspondence between the two coders’ judgments on each of the trials across the six children. Reliability was high, $r = .93$, with a mean difference between the two coders of 630 ms.

Results

**Search Accuracy.** The first question addressed was whether children were more likely to search initially at the correct location in response to nonambiguous than to ambiguous descriptions. Percentages of correct searches in response to ambiguous and to nonambiguous descriptions were entered into an Age (3 years vs. 4 years vs. 5 years) × Description Type (ambiguous vs. nonambiguous) repeated measures ANOVA with the first factor as a between-subjects variable and the second as a within-subjects variable. This analysis revealed significant effects of age, $F(2,33) = 5.38, p < .01$, and description type, $F(1,33) = 57.79, p < .001$. Four- and 5-year-olds produced a greater percentage of correct searches ($M = 78\%$ and $M = 78\%$, respectively) than did 3-year-olds ($M = 64\%$). All three age groups, however, searched at the correct location on a greater percentage of the nonambiguous ($M = 90\%$) than the ambiguous ($M = 56\%$) trials. This analysis shows that all age groups correctly comprehended nonambiguous descriptions and that there were no reliable cues to the location of the mouse on the ambiguous trials.

An additional analysis was conducted to determine whether children’s errors on ambiguous trials were confined to the nontarget members of the small landmark pairs. Scores were calculated by dividing the number of ambiguous trials in which children searched at the nontarget member of the small landmark pair by the total number of ambiguous trials in which children made errors. Across the three age groups, 96% of all errors on the ambiguous trials involved searches at the nontarget member of the small landmark pair. A one-way ANOVA revealed that such errors did not differ according to age, $F(2,32) = .66, ns$. (One 5-year-old was not included in this
analysis because she made no errors on ambiguous trials.) Thus, when given an ambiguous description, children narrowed their search to the relevant pair of identical small landmarks.

**Search Latencies.** Of primary interest to the investigation presented here was whether children detected ambiguity in spatial descriptions. That is, were they slower to search in response to ambiguous descriptions than to nonambiguous descriptions? Prior to statistical analysis, search latencies that were three or more standard deviations greater than the mean for each description type within each age group were classified as outliers and removed. The total number of outliers removed for 3-, 4- and 5-year-olds was 2, 3, and 3, respectively. Mean search latencies were entered into an Age (3 years vs. 4 years vs. 5 years) × Description Type (ambiguous vs. nonambiguous) repeated measures ANOVA with the first factor as a between-subjects factor and the second as a within-subjects factor. This analysis yielded a significant main effect of description type, $F(1, 33) = 4.46, p < .05$.

This effect, however, was subsumed under a significant Age × Description Type interaction, $F(2, 33) = 7.05, p < .01$. As shown in Figure 2, 3-year-olds were slower to search in response to *nonambiguous* descriptions than ambiguous descriptions. In contrast, 4- and 5-year-olds were slower to search in response to ambiguous than to nonambiguous descriptions. Simple effects tests revealed that search times for ambiguous and nonambiguous descriptions were significantly different for 4-year-olds, $F(1, 11) = 5.76, p < .05$, and for 5-year-olds, $F(1, 11) = 10.96, p < .01$, but not for 3-year-olds, $F(1, 11) = 2.73, p = .13$. In terms of percentage differences, 4- and 5-year-olds were 27% and 37% faster to search in response to nonambiguous than to ambiguous descriptions, whereas 3-year-olds were 21% faster to search in response to ambiguous than to nonambiguous descriptions.

**Discussion**

The results of this experiment clearly show that 4- and 5-year-olds detected spatial ambiguity. Although they rarely asked questions about the location of the mouse, they hesitated longer when the description did not distinguish between the two identical hiding spots. Three year olds, on the other hand, did not hesitate longer for ambiguous than nonambiguous descriptions. In fact, they exhibited a tendency to hesitate longer when descriptions were nonambiguous than when they were ambiguous. Together, these results suggest that there are developmental differences in 3- and 5-year-olds' ability to detect ambiguity in spatial descriptions. That is, by about 4 or 5 years of age, children respond to ambiguous descriptions with uncertainty even though they rarely verbalize that uncertainty.

The goal of Experiment 2 was to determine if the developmental pattern found in Experiment 1 was replicable. Although always desirable, rep-
Figure 2. Mean search latencies in Experiment 1 as a function of age and description type.
lication is particularly important at this juncture because the children in Experiment 1 participated in a direction-giving task prior to the ambiguity detection task. Because the experience of giving directions might have influenced children's performance in the ambiguity detection task, a second experiment was conducted to replicate the findings of Experiment 1. The dollhouse and procedures were identical to those of Experiment 1. It was expected that 3-year-olds would exhibit longer search latencies to nonambiguous than to ambiguous descriptions, and that 5-year-olds would exhibit longer search latencies to ambiguous than to nonambiguous descriptions.

EXPERIMENT 2

Method

Participants. Twelve 3-year-olds and twelve 5-year-olds from predominantly middle- to upper middle-class Caucasian families participated in the study. The mean ages were 3 years, 5 months (range = 3 years, 2 months to 3 years, 11 months) and 5 years, 7 months (range = 5 years, 5 months to 5 years, 9 months). There were 9 boys and 3 girls in the 3-year-old group, and 6 boys and 6 girls in the 5-year-old group. Children were recruited in the same manner as in Experiment 1.

Apparatus and Materials. The apparatus and materials were the same as in Experiment 1 with the following exceptions. The small landmarks included identical pairs of shoes, plants, paper bags, hats, pillows, shovels, baskets with cloths inside them, and pots with lids. The large landmarks included a bookshelf, table, dresser, bed, couch, TV, piano, and chair. The layout of landmarks within the dollhouse also was changed to make it possible to determine whether children used a strategy of searching the small landmark closest to themselves on the ambiguous trials.

Design and Procedure. The same familiarization and testing procedures were used as before with the exception that only four of the eight pairs of identical small landmarks in the dollhouse served as hiding locations. Two sets of four pairs of identical small landmarks were randomly constructed and counterbalanced across the two age groups. Each of the four pairs served as a hiding location twice, once for an ambiguous description and once for a nonambiguous description. The member of each pair that served as the target location, however, was randomly chosen. The order of ambiguous and nonambiguous descriptions and the order of hiding locations also were randomized across the children.
**Measures.** Search latencies were coded in the same manner as before. Questions about the location of the mouse on ambiguous trials again were relatively uncommon, occurring on only 13% of ambiguous trials. Inter-coder reliabilities were calculated in the same manner as Experiment 1 on six randomly chosen children. Reliability for search latencies again was high, \( r = .95 \), with a mean difference of 499 ms between the two coders.

**Results**

**Search Accuracy.** The mean percentages of correct searches in response to ambiguous and nonambiguous descriptions were entered into an Age (3 years vs. 5 years) × Description Type (ambiguous vs. nonambiguous) repeated measures ANOVA with the first factor as a between-subjects variable and the second as a within-subjects variable. As before, this analysis revealed a significant effect of description type, \( F(1, 22) = 48.52, p < .001 \). Both 3- and 5-year-olds searched the correct location in a greater percentage of the nonambiguous (\( M = 95\% \)) than the ambiguous (\( M = 50\% \)) trials. Thus, both age groups correctly comprehended nonambiguous descriptions and that there were no reliable cues to the location of the mouse on the ambiguous trials.

Two additional analyses were carried out to examine whether children exhibited any systematic biases in where they chose to search on the ambiguous trials. First, were errors confined to the nontarget members of the small landmark pairs? Across the two age groups, 92% of all errors on the ambiguous trials involved searches at the nontarget member of the small landmark pair. A one-way ANOVA revealed that such errors did not differ according to age, \( F(1, 20) = 2.11, \text{ns} \). (One 3-year-old and one 5-year-old were not included in this analysis because they made no errors on ambiguous trials.) Thus, when given an ambiguous description, children again narrowed their search to the relevant pair of identical small landmarks.

Given that children almost always searched at one of the two members of the small landmark pairs on ambiguous trials, did children adopt a strategy of searching at the member of the small landmark pair closest to themselves? Percentage scores were calculated by dividing the number of ambiguous trials in which children searched at the closest of the two small landmarks by the total number of ambiguous trials (excluding those trials in which children asked a question about the location of the mouse or searched somewhere other than at one of the two small landmarks). Scores were compared to chance (\( p = .50 \)) using one-sample \( t \) tests. These analyses revealed that the percentage of trials in which children searched at the closest small landmark was significantly above chance for 5-year-olds (\( M = 65\% \)), \( t(11) = 2.24, p < .05 \), but not for 3-year-olds (\( M = 64\% \)), \( t(10) = 1.70, \text{ns} \). This suggests that 5-year-olds, but not 3-year-olds, were biased to search
at the small landmark closest to themselves when they received ambiguous
descriptions about which of the two landmarks contained the mouse.

**Search Latencies.** The question of primary interest was whether the
developmental pattern observed in Experiment 1 was replicable. The number of
outliers removed for 3- and 5-year-olds was 3 and 1, respectively. Mean search
latencies were entered into an Age (3 years vs. 5 years) × Description Type
(ambiguous vs. nonambiguous) repeated measures ANOVA. This analysis
yielded a significant main effect of age, $F(1, 22) = 9.80, p < .01$.

More important, there again was a significant Age × Description Type
interaction, $F(1, 22) = 11.79, p < .01$. As shown in Figure 3, 3- and 5-year-
olds again exhibited opposite patterns of responding. Simple effects tests
revealed that 3-year-olds were significantly slower to search in response to
nonambiguous than to ambiguous descriptions, $F(1, 11) = 6.09, p < .05$, but
that 5-year-olds were significantly slower to search in response to ambigu-
ous than to nonambiguous descriptions, $F(1, 11) = 7.65, p < .05$. In relative
terms, 3-year-olds were 33% faster to search in response to ambiguous than
to nonambiguous descriptions, whereas 5-year-olds were 27% faster to
search in response to nonambiguous than to ambiguous descriptions.

**Discussion**
The results of this experiment confirm the developmental pattern observed
in Experiment 1. That is, 5-year-olds again were slower to search in response to
ambiguous than to nonambiguous descriptions, but 3-year-olds were
slower to search in response to nonambiguous than to ambiguous descrip-
tions. It seems clear that 5-year-olds’ hesitation reflected their uncertainty
about the ambiguous descriptions. But why did 3-year-olds hesitate longer
in response to nonambiguous than to ambiguous descriptions? One possible
explanation is that 3-year-olds were responding to the differential complex-
ity of ambiguous and nonambiguous descriptions. Recall that nonambigu-
ous descriptions referred to the spatial relation between two landmarks, the
primary landmark and the secondary landmark (e.g., “It’s in the bag next to
the piano”). Ambiguous descriptions, on the other hand, referred to two
landmarks (e.g., “It’s in one of the bags”), but not to a spatial relation
between them. Three-year-olds may have had difficulty processing the infor-
mation about the two landmarks and the spatial relation between them.
Thus, the longer search latencies for nonambiguous descriptions may reflect
the additional processing time needed to comprehend such descriptions. It
is important to point out that 3-year-olds almost always found the mouse on
the first try when given a nonambiguous description and therefore were not
confused by the nonambiguous descriptions.

Another possible explanation for why 3-year-olds hesitated longer for
nonambiguous than for ambiguous descriptions is that they were using
Figure 3. Mean search latencies in Experiment 2 as a function of age and description type.
different strategies for the two types of descriptions. When faced with an ambiguous description, 3-year-olds may have detected that the description was ambiguous, but without enough information to be confident of finding the mouse on the first try, they may have opted to search quickly. When faced with a nonambiguous description, however, 3-year-olds may have executed a slower and more careful search because they recognized that they had enough information to find the mouse on the first try.

One way to distinguish among these alternative explanations is to equate the amount of information in ambiguous and nonambiguous descriptions. In Experiment 3, four pairs of identical primary landmarks served as hiding locations for ambiguous descriptions, but four single primary landmarks served as hiding locations for the nonambiguous descriptions. Therefore, nonambiguous descriptions referred to one unique primary landmark (e.g., "It's under the hat"), and ambiguous descriptions again referred to one of two identical primary landmarks (e.g., "It's in one of the baskets"). If 3-year-olds' longer search latencies for nonambiguous than for ambiguous descriptions in the previous two experiments were due to comprehension difficulties, then when the amount of information is equated across the two types of descriptions one might expect that either: (a) They would exhibit no difference in their search latencies for ambiguous and for nonambiguous descriptions; or (b) They would exhibit shorter search latencies for nonambiguous than for ambiguous descriptions. Alternatively, if 3-year-olds' longer search latencies for nonambiguous than for ambiguous descriptions were due to strategy differences, then when the amount of information is equated across the two types of descriptions, one still would expect longer latencies for nonambiguous than for ambiguous descriptions.

**EXPERIMENT 3**

**Method**

**Participants.** Twelve 3-year-olds and twelve 5-year-olds from predominantly middle- to upper middle-class Caucasian families participated in the study. The mean ages were 3 years, 5 months (range = 3 years, 0 months to 3 years, 9 months) and 5 years, 5 months (range = 5 years, 0 months to 5 years, 9 months). There were 7 boys and 5 girls in the 3-year-old group, and 5 boys and 7 girls in the 5-year-old group. Children were recruited in the same manner as in Experiments 1 and 2.

**Apparatus and Materials.** All materials were the same as in Experiment 2 with the exception that there were four pairs of identical small landmarks and four single small landmarks. Small landmarks were randomly designated as pairs or singles across children.
**Design and Procedure.** The same familiarization and testing procedures were used as in Experiments 1 and 2. There were eight test trials involving the four pairs of identical small landmarks and the four single small landmarks. The pairs of identical small landmarks were used for the ambiguous descriptions and the single small landmarks were used for the nonambiguous descriptions. The ambiguous descriptions were the same as in Experiments 1 and 2 (e.g., “It’s under one of the pillows”), but the nonambiguous descriptions referred only to the small landmark (e.g., “It’s under the hat”) rather than to the spatial relation between the small and large landmark (e.g., “It’s under the hat next to the chair”). The order of ambiguous and nonambiguous descriptions and the order of hiding locations were randomized across children.

**Measures.** Search latencies were coded in the same manner as in the previous experiments. Questions about the location of the mouse on ambiguous trials again were relatively uncommon, occurring on only 5% of ambiguous trials. Intercoder reliabilities were calculated in the same manner as the previous experiments on six randomly chosen children. Reliability was $r = .87$, with a mean difference of 682 ms between the two coders.

**Results**

**Search Accuracy.** The mean percentage of correct searches was entered into an Age (3 years vs. 5 years) × Description Type (ambiguous vs. nonambiguous) repeated measures ANOVA. This analysis yielded a significant main effect of description type, $F(1, 22) = 43.46, p < .0001$. Children of both ages were more likely to search at the correct location in response to nonambiguous ($M = 96\%$) than to ambiguous ($M = 58\%$) descriptions. As in the previous experiments, both age groups correctly comprehended nonambiguous descriptions and there were no reliable cues to the location of the mouse on the ambiguous trials.

As before, additional analyses were carried out to examine whether children exhibited any systematic search biases on ambiguous trials. Consistent with the previous experiments, all errors made by the 3- and 5-year-olds on the ambiguous trials involved searches at the nontarget member of the identical landmark pair. (Two 3-year-olds and two 5-year-olds were not included in this analysis because they made no errors on ambiguous trials.)

The second analysis examined whether children adopted a strategy of searching at the member of the small landmark pair closest to themselves. The percentage of trials in which children searched at the closest small landmark was significantly above chance for 5-year-olds ($M = 69\%$), $t(11) = 2.28, p < .05$, but not for 3-year-olds ($M = 65\%$), $t(10) = 2.03, ns$. This again shows that 5-year-olds, but not 3-year-olds, were biased to search at
the small landmark closest to themselves when they were given ambiguous descriptions about which of the two landmarks contained the mouse.

**Search Latencies.** The question of primary interest was whether 3- and 5-year-olds would treat ambiguous and nonambiguous descriptions differently when the nonambiguous descriptions included only a reference to a single landmark. The number of outliers removed for 3- and 5-year-olds was 4 and 1, respectively. Mean search latencies were entered into an Age (3 years vs. 5 years) × Description Type (ambiguous vs. nonambiguous) repeated measures ANOVA. This analysis yielded a significant Age × Description Type interaction, \( F(1, 22) = 7.11, p < .05 \). As shown in Figure 4, 3- and 5-year-olds again exhibited different patterns of responding. Simple effects tests revealed that 5-year-olds' search latencies to ambiguous descriptions were significantly slower than those to nonambiguous descriptions, \( F(1, 11) = 8.31, p < .05 \), but that 3-year-olds' search latencies to ambiguous and to nonambiguous descriptions were not significantly different, \( F(1, 11) = .70, ns \). In terms of percentages, 3-year-olds were only 9% faster to search in response to ambiguous than to nonambiguous descriptions, whereas 5-year-olds were 38% faster to search in response to nonambiguous than to ambiguous descriptions.

**Discussion**
The results of this experiment clearly show that when nonambiguous descriptions did not include a reference to a spatial relation between two landmarks, 3-year-olds' search latencies in response to ambiguous and to nonambiguous descriptions were not significantly different. Five-year-olds again exhibited their typical pattern of slower search latencies for ambiguous than for nonambiguous descriptions. These findings suggest that 3-year-olds' longer search latencies for nonambiguous than for ambiguous descriptions in the two previous experiments reflected additional processing time needed to comprehend nonambiguous descriptions rather than different response strategies for ambiguous and nonambiguous descriptions. Thus, it does not appear that 3-year-olds detected spatial ambiguity in the investigation presented here.

**GENERAL DISCUSSION**
The results of these experiments clearly show that there are developmental differences in how 3- to 5-year-old children treat ambiguous and nonambiguous spatial descriptions. Specifically, 3-year-olds hesitated longer on nonambiguous than on ambiguous trials when the nonambiguous descriptions contained a reference to a spatial relation between two landmarks. Their search latencies on ambiguous and nonambiguous trials were not
Figure 4. Mean search latencies in Experiment 3 as a function of age and description type.
significantly different, however, when the nonambiguous descriptions contained a reference to a single landmark. This pattern of results suggests that they were responding to the complexity of the spatial information in the descriptions rather than to the presence or absence of spatial ambiguity in the descriptions. Four- and 5-year-olds, on the other hand, exhibited slower search latencies in response to ambiguous than to nonambiguous descriptions, suggesting that they detected spatial ambiguity. This pattern of results maps remarkably well onto recent investigations of young children's production of spatial descriptions (Plumert et al., 1993), suggesting that developmental differences in children's ability to detect ambiguity in descriptions of location are related to developmental differences in children's ability to produce unambiguous descriptions of location.

Do these findings show that 4- and 5-year-olds have an explicit awareness of spatial ambiguity? Clearly, their hesitation in response to ambiguous descriptions could reflect either explicit or implicit awareness of spatial ambiguity. However, the fact that 4- and 5-year-olds rarely asked questions about the location of the mouse suggests that they do not have explicit understanding of spatial ambiguity. Thus, it appears that implicit understanding of spatial ambiguity precedes explicit understanding of spatial ambiguity. That is, by age 4 or 5, children respond to ambiguous spatial messages with uncertainty, but do not understand the implications of uncertainty for evaluating the clarity of spatial messages. Clements and Perner (1994) used a similar argument to explain why very young children look at the correct location in a false belief task even though they answer incorrectly about where the protagonist will search. They suggest that the ability to represent a situation occurs developmentally prior to the ability to make a judgment about that situation. The investigation presented here suggests that similar sorts of shifts in implicit to explicit knowledge may also occur in young children's understanding of spatial ambiguity.

What factors might account for the developmental changes observed here in children's comprehension of spatial descriptions? First, developmental changes in basic information-processing capacities may influence how children respond to information in spatial messages. Limitations in processing resources may make it impossible for very young children to engage in any sort of in-depth processing of spatial descriptions. Three-year-olds may have so much difficulty comprehending what is being said to them that they are unable to process the information further. Five-year-olds, on the other hand, may have less trouble comprehending spatial information and therefore may be able to devote more processing resources to processing the adequacy of the information. Indirect support for this hypothesis comes from extensive documentation of developmental changes during early childhood in children's basic information-processing capabilities (for reviews see Case, 1985; Siegler, 1989). Note, however, that because develop-
mental changes in processing capabilities and language skills occur at similar times, it may be impossible to disentangle the two.

The results of the investigation presented here support the claim that younger children were more influenced than older children by the processing demands of the task. Although the 3-year-olds correctly comprehended nonambiguous descriptions, they took longer to respond to nonambiguous than to ambiguous descriptions when the nonambiguous descriptions referred to the spatial relation between two landmarks (e.g., "It's in the bag next to the chair"). This was not the case when the nonambiguous descriptions referred to only a single landmark (e.g., "It's in the bag"). The longer search latencies likely reflect the additional processing time 3-year-olds needed to comprehend the more complex descriptions. Five-year-olds, on the other hand, responded more quickly to nonambiguous than to ambiguous descriptions regardless of whether the nonambiguous descriptions were complex or simple.

A second factor that may influence children's ability to detect ambiguity in spatial descriptions is developmental change in metacognitive knowledge. One aspect of metacognitive knowledge that may play an important role is children's knowledge about the rules of communication. In particular, young children may not understand that when they are on the receiving end of a spatial message, they should evaluate whether the message distinguishes between the target location and other potentially confusable locations. The fact that 4- and 5-year-olds, but not 3-year-olds, exhibited longer search latencies to ambiguous than to nonambiguous descriptions is consistent with referential communication studies that have investigated young children's recognition of ambiguity in nonspatial tasks (Bearison & Levey, 1977; Patterson et al., 1980). According to Robinson and Robinson (1976), younger children do not understand the link between the quality of the message and the likelihood of communicative success and therefore have difficulty distinguishing between ambiguous and nonambiguous messages.

Another aspect of metacognitive knowledge that may contribute to children's detection of spatial ambiguity is knowledge about what it means to "know" where something is. Numerous studies have documented developmental changes between age 3 and 5 in children's understanding of the relation between beliefs and actions (e.g., Avis & Harris, 1991; Bartsch & Wellman, 1989; Wellman, 1990; Wimmer & Perner, 1983). Much of this work centers around young children's performance in false belief tasks. In a typical false belief task, children watch an experimenter place an object at a location and then leave the room. After the first experimenter leaves the room, a second experimenter moves the object to a different location. Children then are questioned about where the first experimenter will think that the object is when he or she comes back. Typically, 3-year-olds do not distinguish between what they themselves know and what the first experi-
menter knows about the location of the object. That is, 3-year-olds usually think that the first experimenter will search at the new location for the object. Older children, on the other hand, understand that the first experimenter will search at the place where he or she last saw the object.

How might developmental changes in children's understanding of what it means to know something be related to children's ability to detect ambiguity in spatial descriptions? Children in the experiments presented here were instructed to find the mouse on the first try and ask questions if they were not sure about where the mouse was hiding. In short, these instructions were designed to emphasize the importance of "knowing" where the mouse was before searching. It may be that 4- and 5-year-olds have some understanding of the difference between knowing and not knowing where something is, but 3-year-olds do not. According to this hypothesis, one way to interpret 4- and 5-year-olds' hesitation to ambiguous descriptions is that at some level they recognized that they did not know which of the two places the mouse was hiding. Three-year-olds, however, may not have understood the implications of being informed that the mouse was located at one of two equally likely hiding spots. This interpretation is consistent with findings showing that 3-year-olds have difficulty understanding the link between knowledge and action (Bartusch & Wellman, 1989).

Third, developmental changes in how children code location may also contribute to children's recognition of spatial ambiguity. Although research on the topic is scarce, the available evidence indicates that children progress from only coding objects in relation to a single landmark, to coding objects in relation to a nested series of landmarks and spatial regions (Bushnell, McKenzie, Lawrence, & Connell, 1995; Cornell & Heth, 1983; DeLoache & Brown, 1983, 1984). DeLoache and Brown (1983), for example, found that 21-month-olds could only remember the spatial relation between a target object and a single landmark, but 26-month-olds could remember both the relation between the target object and the primary landmark and the relation between the primary landmark and the secondary landmark. Thus, when the target object was hidden in one of four identical containers that were located on or near pieces of furniture, only the older children successfully retrieved the toy after a delay. Recent evidence suggests that the ability to communicate about nested spatial relations undergoes a similar pattern of development (Craton et al., 1990; Plumert et al., 1995; Plumert et al., 1994). That is, at age 3, children typically describe an object in relation to only a single landmark (e.g., "It's in the wastebasket"), but by age 6, they describe an object in relation to a nested series of landmarks and spatial regions (e.g., "it's in the wastebasket by the bed in my room").

How might these developmental changes in children's coding of location influence their ability to detect ambiguity in spatial descriptions? If young children typically think of object locations only in terms of single landmarks,
then they may not realize that a statement such as "The mouse is in one of the bags" does not clearly specify the location of the mouse. If older children, however, typically think of object locations in terms of nested landmarks and spatial regions, then they may more easily recognize when a description does or does not adequately specify a location.

Quite possibly, developmental changes in information-processing capabilities, metacognitive skills, and spatial knowledge work together in complex ways to produce changes in children's ability to detect spatial ambiguity. For example, increased information-processing capabilities may allow children to devote more cognitive resources to developing their understanding of the rules of communication. Likewise, children's developing understanding of the rules of communication may aid in directing their attention to more relevant features of the task and hence free up further processing resources. More sophisticated ways of representing location may help children better understand how their own knowledge may differ from that of their listener. Further research, however, is needed before any definitive conclusions can be drawn about how improvements in each of these three areas affect young children's ability to detect spatial ambiguity.

REFERENCES


