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Infants Interpret Ambiguous Requests for Absent Objects

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The current studies investigated 2 skills involved in 14- to 20- month-olds' ability to interpret ambiguous requests for absent objects: tracking others' experiences (Study 1) and representing links between speakers and object features across present and absent reference episodes (Study 2). In the basic task, 2 experimenters played separately with a different ball. The balls were placed in opaque containers. One experimenter asked infants to retrieve her ball using an ambiguous request ("Where's the ball?"). In Study 1, infants used the experimenter's prior verbal and physical contact with the ball to interpret the request. A control condition demonstrated that infants were interpreting the request and not responding to the mere presence of the experimenter. Study 2 revealed that only infants who were given stable cues to the ball's spatial location appropriately interpreted the request: When spatial information was put in conflict with a color cue, infants did not select the correct ball. Links to infants' spatial memory skills and emerging pragmatic understanding are discussed.

Keywords: language development, theory of mind, spatial memory, pragmatic competence

Absent reference comprehension is a pivotal accomplishment of early life. Its emergence supports development in a variety of areas including concept formation and memory, as it takes language beyond the concrete present to entities that are abstract and hypothetical. Previous research has demonstrated that such comprehension emerges across infants' second year (Ganea, 2005; Huttenlocher, 1974; Miller, Chapman, Branston, & Reichle, 1980; Sachs, 1983; Saylor, 2001, 2004; Saylor & Baldwin, 2004). However, it is still not clear what skills support its emergence. The current research addresses this gap. Before detailing the current studies, we describe a task that is central to understanding absent reference to set the stage for a discussion of two skills infants may recruit when interpreting such references.

Decoding References to the Absent

Oftentimes when speakers refer to absent things, the referent is quite clear. For example, if a speaker uses a term that picks out a unique individual (e.g., "Todd" or "the moon") or if there is only one referent available, then identifying the referent may be relatively unproblematic. Previous research has revealed that infants from 13 months can interpret such unambiguous absent references (e.g., Ganea, 2005; Saylor, 2004). However, absent reference will often be less transparent because there may be multiple possible exemplars that an expression can refer to. For example, if a father refers to "the dog," an infant only understands the reference if she identifies the particular dog that is specific to her shared experience with a dog but not to dogs in general or dogs that she has seen with other people. In this case, the infant's task is to identify the particular category member a speaker is referring to. To do so, infants must track others' experiences vis-à-vis referent objects and maintain links between people and objects across present and absent reference episodes. We discuss each skill and its relation to absent reference understanding below.

Tracking Others' Experiences

To track others' experiences vis-à-vis referent objects, infants must recognize which category member the speaker is familiar with. Research on adults' pragmatic competence suggests that the endpoint of this skill is recognizing what knowledge is shared between speakers (i.e., mutual knowledge; Clark & Marshall, 1981; Pickering & Garrod, 2004). Inferences about mutual knowledge involve recognizing (a) how experiences affect knowledge states (e.g., seeing = knowing) and (b) iterative relationships between the knowledge states of self and other (e.g., "I know that you know that I know that you know . . ."). In other words, to determine whether something is mutually known, speakers need to recognize that knowledge of something exists in the mind of their interlocutor and to recognize the relationship between their own knowledge states and others' knowledge states. These skills may be out of infants' reach for two reasons. First, the recognition of causal relationships between experiences and knowledge states does not emerge until the preschool years (e.g., Montgomery, 1992). Next, infants' limited processing resources may make it difficult to represent iterative relationships.

Infants may track others' experiences using the more modest strategy of noting which objects and events their speech partners

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have had perceptual contact with (see O'Neill, 1996, and Tomasello & Haberl, 2003, for similar proposals). This can be accomplished by tracking physical (touching) and verbal (talking about) proximity between speech partners and objects and events. Clark and Marshall (1981) argued that representations of contact between people and things are involved in interpreting others' references. For example, when a speaker refers to "the candle," a listener may think back to which candle the speaker came into contact with. Of note, it is possible to form and maintain associations between people and things without engaging in explicit reasoning about how such associations causally relate to knowledge states. In some formulations of adults' mutual knowledge understanding, reasoning about others' knowledge states is argued to occur at a later stage of processing (e.g., Keysar, Barr, Balin, & Brauner, 2000) or not to occur at all (Pickering & Garrod, 2004). Hence, it seems possible that young infants would be able to track others' experiences to interpret absent reference by noting physical and verbal copresence between speakers and things.

While there is ample evidence that 12- to 18-month-olds track others' experiences to interpret present reference (e.g., Akhtar & Tomasello, 1996; Ganea & Saylor, in press; Kuhlmeier, Wynn, & Bloom, 2003; Liskowski, Carpenter, Henning, Striano, & Tomasello, 2004; Tomasello & Haberl, 2003), less evidence is available regarding infants' ability to track others' experiences to interpret absent reference. In one study, O'Neill (1996) demonstrated that 24- to 30-month-olds use others' physical contact with objects to design their references to absent things. In her study, toddlers requested absent objects. Physical contact was manipulated by having their speech partner be either in the room or out of the room when the objects were hidden. Toddlers adjusted the content of their requests according to the physical contact between their speech partner and the object. For example, children included more gestures when their mother did not see the object being hidden. This suggests that children used information about the others person's prior experience when making a request for an absent object. One question is whether infants reveal similar skills as they begin to understand absent reference during their second year. We investigated this possibility in Study 1 by asking whether infants can use others' verbal and physical contact with objects to interpret an ambiguous request for an absent object.

Maintaining Links Between Speakers and Objects

To identify the speaker's intended referent during absent reference, infants also need to form representations of links between people and objects. Once formed, the representations can be used to determine which member of a category the speaker is referring to. Research on feature binding suggests that infants have the basic skills to form such representations by their first birthday, because they can represent features of objects over brief occlusions (e.g., Kaldy & Leslie, 2003; Oakes, Ross-Sheeley, & Luck, 2006; Ross-Sheeley, Oakes, & Luck, 2003). However, the ability to represent features of objects may initially be somewhat limited. In particular, infants show more robust tracking of objects using spatial and temporal information than information related to object kind (e.g., color and shape; Tremoulet, Leslie, & Hall, 2000; Xu, 1999; Xu & Carey, 1996; Xu, Carey, & Welch, 1999). In essence, infants are better able to encode some features over others. One possibility is that infants' initial ability to interpret absent reference will be tied to the presence of a key set of object features, such as stable spatial locations. The presence of such features may help infants represent links between people and referent objects. We investigated this possibility in Study 2.

Study 1

In Study 1, we focused on infants' ability to track others' experiences with objects during absent reference understanding. In the most basic condition, two experimenters each played separately with infants with a different object. The objects were identical to one another except for their color (e.g., a red ball and a blue ball). During a play period, the experimenters each handled and talked about their object to give infants physical and verbal cues to the contact between each experimenter and her object. Except when each experimenter played with her object, the test objects were kept out in opaque containers, so they were absent. During the critical test phase, one experimenter requested an object using an ambiguous request (e.g., "Where's the ball?"). Infants' task was to select the object the requester played with. We used an ambiguous request so that infants could not interpret the absent reference on the basis of labels that identified a unique referent (e.g., "the red ball"). Instead, they had to refer back to their prior experience with the experimenter to appropriately interpret her request.

One possibility was that infants could succeed at the task if they ignored the verbal request and responded solely to the presence of the experimenter. To isolate the role of the requester, we designed a condition in which we removed the verbal request but left everything else the same. The prediction was that if infants were interpreting the verbal request, rather than responding to the mere presence of the experimenter, they should be at chance in their selection of the target object. In contrast, if infants could succeed at the original task by attending to the presence of the experimenter alone, they should continue to select the target object at above-chance levels, even when no request was made.

We began the current investigation with infants at 15 and 18 months. We chose these age groups because previous research suggested that infants' absent reference comprehension matures across these two time periods (e.g., Huttenlocher, 1974; Miller et al., 1980; Sachs, 1983; Saylor, 2001; Saylor & Baldwin, 2004). However, data from the two age groups were virtually identical. For ease of discussion, we therefore present the results collapsed across age.

Method

Participants

Seventy-two infants ranging in age from 14 months 7 days to 20 months 11 days participated (M = 17 months 0 days; 36 boys and 36 girls). All infants who participated were full term at birth, had intact hearing, were developing normally, and had language input that was comprised of 95% or more English. Infants and their parents were recruited by phone from a database of families interested in research participation in a primarily Caucasian, middle-class community. Data from 9 infants were excluded for fussiness (1), experimenter error (3), parental interference (2), and refusal to play with the stimuli (3).

Materials

Stimuli. During the experimental session, infants were shown a red ball and a blue ball. The balls were kept in opaque sandbox buckets matching their color. Prior to participation, a phone questionnaire confirmed that infants understood the label "ball."

Equipment. A Canon MiniDV video camera was used to film the session. In addition, the experimenters used a stopwatch to time their sessions with infants.

Design

The design of the study was between subjects. Infants were randomly assigned to either the request (n = 32) or no-request (n = 32) condition so that the mean ages were equal and there were roughly equal numbers of boys and girls in each condition. The request condition investigated whether infants would use others' physical and verbal contact with objects to interpret an ambiguous request. The no-request condition investigated whether infants could succeed in the request condition by ignoring the verbal request and simply attending to the presence of the experimenter.

Procedure

Infants were tested in a rectangular room with 1.37-m tall file cabinets lining the long right wall. Upon arrival, parents were asked to sit along the short wall that ran perpendicular to the file cabinets. They remained in their spot throughout the entire session. Infants were free to roam around the space (see Figure 1).

During the session, infants played with two experimenters (E1 and E2). The experimenters were chosen to be physically distinct from one another so that infants would not confuse them. This goal was accomplished by choosing experimenters who were from different ethnic groups or who had markedly different hairstyles if ethnic group was constant. There were no differences in infants' responding based on experimenter pair. One experimenter was assigned to the requester role prior to the session.

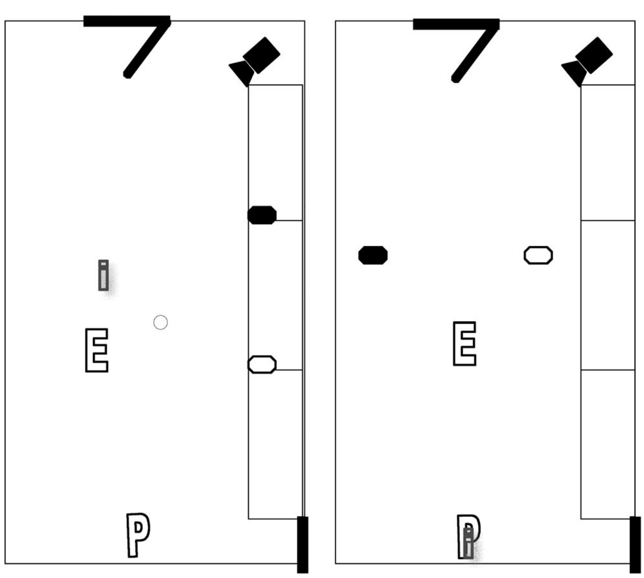

Figure 1. Room setup for Study 1 for the ball introduction (left) and the test phase (right). The camera is shown in the top right corner. E = experimenter; P = parent.

In addition, infants only saw one experimenter at a time during critical segments of the experiment: when each experimenter played with an object, when objects were placed on the floor, and when a request was made. This was accomplished by having one experimenter leave the room while the other interacted with the infant. To ensure that infants remembered that there were two experimenters, we had E1 and E2 appear together prior to each of the critical segments.

The experimental session was divided into two phases: ball introduction and test. The purpose of the ball introduction phase was to give infants ample verbal and physical cues to the contact between each experimenter and an object. The purpose of the test phase was to investigate whether infants used such cues to interpret an ambiguous request for an absent object.

Ball introduction. For the entire ball introduction phase, the two buckets were placed 0.91 m apart on the file cabinets in a set spatial position. For example, the red bucket was to the right of the blue bucket. A ball was inside of each bucket.

During the ball introduction phase, infants saw each experimenter paired with one of the balls for 1 min and heard each experimenter label her ball seven times. At the start of the ball introduction phase, E1 extracted her ball from the bucket (e.g., the blue ball from the blue bucket) and said, "Here's my *ball*!" She sat on the floor and played with the infant for 1 min. During the 1-min long play period, E1 rolled, bounced, or threw the ball according to infants' interests. In doing so, she said "ball" five times as she commented on infants' actions (e.g., "Are you throwing the *ball*? Can you give me the *ball*?"). When not mentioning the ball, the experimenter made general comments about infants' activities (e.g., "Are you having fun? What's mommy doing?"). At the end of the 1 min of play, E1 put the ball inside its bucket and said, "My *ball* goes here." E2 then repeated the entire sequence with the other ball. The test phase occurred next.

Test phase. The test phase began when one experimenter asked parents to hold their infant on their lap. Each experimenter then separately placed her bucket on the floor in the same spatial position it had been on the cabinet 1.52 m away from the infant and parent. For example, E1 put her bucket on the left and E2 placed her bucket on the right. The buckets were 1.22 m apart. As the buckets were placed on the floor, the experimenters said, "My *ball* goes right here." Following this statement, one experimenter sat in front of the buckets facing the infant. This was to ensure that she could not influence infants' responding by looking at the objects during the test phase (see Figure 1). In the request condition, she said, "Where's the ball?" In the no-request condition, she sat silently in front of the buckets for 2 s (the length of time it took to make the verbal request). After the request or silent pause, parents were instructed to release their infant. In particular, the experimenter said, "You can let him/her go now." For both conditions, the experimenter looked toward the parent until infants selected a ball (to avoid biasing their selection with a head movement). Once infants made their selection, the experimenter clapped and said thank you. Which ball served as the target, the side the target appeared on, and whether E1 or E2 was the requester were counterbalanced across participants.

Coding

Infants were categorized according to whether they selected the ball that the experimenter played with. These responses were coded during the session by the experimenter, who recorded which ball infants had in hand at the end of the session. In the rare cases where infants would not approach the buckets (4 infants), the experimenter repeated her request twice. If infants still did not respond, she reached behind herself and pulled the buckets forward. If there was no response at that point, the experimenter ended the session and infants' first look or point to one of the buckets' locations (after the silent pause or the request) was coded from the videotape. The experimenter's coding of infants' ball selection and the first look or point data are reported in the *Results* section.

A second coder, naive to which experimenter played with which ball, coded the ball infants chose for 85% of the sessions.[1] The coders disagreed on only five trials (93% agreement, $\kappa = .85$, $p < .05$). Disagreements were resolved via discussion.

Results

The main question in Study 1 was whether infants used others' physical and verbal contact with an object to interpret an ambiguous request for an absent object. If they did, they were predicted to choose the object that the experimenter had played with previously. To investigate this possibility, we performed two analyses. In the first, we compared the number of infants who selected the target object in the request condition with the number of infants who selected the object in the no-request condition using a chi-square test of association. The analysis revealed that more infants in the request condition (28 of 36) selected the correct object than infants in the no-request condition (18 of 36), $\chi^2(1, N = 36) = 6.02$, $p < .01$. In addition, the reliability of infants' responding was compared with chance levels using a binomial test. Infants' responding differed from chance levels only in the request condition ($p < .05$). See Figure 2 for a summary of the results.

Together these analyses reveal that infants only reliably selected the target object in the request condition. The fact that infants did not tend to select the target object in the no-request condition demonstrates that they were interpreting the experimenter's verbal request in the request condition. The mere presence of the experimenter alone was not sufficient to engender reliable responding.

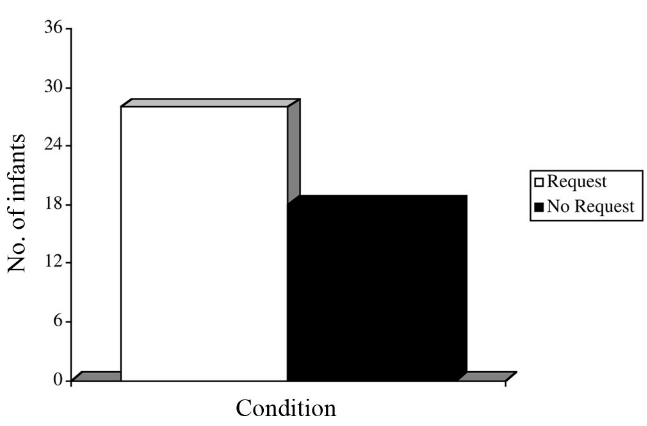

Figure 2. Number of infants selecting the correct object in Study 1 in each condition.

The session tapes revealed some minor differences in the play sessions. These arose for two reasons. First, differences in the interests and moods of individual infants led to variations in how much the experimenters said. Next, human error led to differences in the number of times the experimenters said the target labels. One concern was that variations in the requester's speech about the balls may have affected infants' responding. To guard against this possibility, we had the ball introduction phase transcribed and coded. This enabled comparisons of the total number of times the experimenters said the word *ball* and the total number of words the experimenters said across the request ($n = 35$) and no-request ($n = 34$) conditions. The first comparison revealed no differences in how many times the experimenters said "ball" across the request (M ball $= 6.62$, $SD = 0.79$) and no-request (M ball $= 6.62$, $SD = 0.84$) conditions: independent-sample $t(67) = 0.06$. The second comparison revealed no differences in the number of words across the request (M words $= 91.76$, $SD = 25.38$) and no-request (M words $= 98.72$, $SD = 20.32$) conditions: independent-sample $t(67) = 1.26$.

These comparisons were also conducted for the requester and nonrequester pairs. The first of the comparisons revealed that the requester (M ball $= 6.86$, $SD = 1.01$) said "ball" an equal number of times as the nonrequester (M ball $= 6.56$, $SD = 1.05$): paired-samples $t(67) = 0.76$. The second of these comparisons revealed that the requester (M words $= 96.29$, $SD = 25.02$) and nonrequester (M words $= 94.09$, $SD = 31.13$) used the same number of words: paired-samples $t(67) = 0.56$. These analyses rule out the possibility that infants' performance was due to differences in the requester's speech about the balls.

To investigate whether the experimenters differed on other dimensions (e.g., enthusiasm), we had a coder watch the ball introduction phase and make judgments about whether E1 or E2 would go on to request the test object. The coder identified the requester only 46% of the time, a value not different from chance by a binomial test. These analyses demonstrate that the requester was not making her interaction more salient than the nonrequester by verbal or other means.

An additional concern was that the requester may have cued infants to select a ball during the test phase. To guard against this possibility, we had the test phase coded to see whether the requester produced any cues that may have led infants to choose one ball over the other (e.g., by turning or leaning to the left or right side). The coder watched the test phase from the time the experimenter sat in front of the buckets until the infant was off of the parent's lap (babies tended to move to the left or right side immediately after this point). Cuing occurred on 28% of the trials (or 19 of 68), and it was slightly more likely to occur in the request (58% of the cues, 11 trials) than no-request (42% of cuing, 8 trials) condition. However, when cuing occurred, it was only predictive

[1] The reliability coding and post hoc coding were conducted from videotapes. Because of poor camera angles, a missing tape, and failure to record the full session, some of the sessions could not be coded in Study 1 and Study 2. The number of sessions coded varies across reliability coding and post hoc coding because different camera views were necessary for the various types of coding.

of the side that the target was on for 32% of cued trials (six trials: four in request, two in no request) and was only predictive of which side the infant went to on 47% of cued trials (nine trials: six in request, three in no request). More important, when trials with explicit cuing were removed from the main analysis, the same pattern of results was obtained: above-chance responding only in the request condition and more correct selection of the target in the request than no-request condition. Hence, cuing on the part of the experimenter during the test phase cannot account for the Study 1 findings.

As an additional check on the presence of cues to select one ball over the other, the coder was asked to guess which ball the requester played with during the ball introduction phase. The coder identified the correct ball only 50% of the time, a value not different from chance by a binomial test. These post hoc analyses rule out the possibility that the experimenters biased infants' responding with variations in their verbal and nonverbal behavior.

Discussion

Infants in Study 1 used information about others' prior experiences with objects to interpret an ambiguous request for an absent object. In particular, they reliably selected the object that the requester had played with, indicating that they used her prior verbal and physical contact with the object to interpret her request. Infants' performance in the no-request condition, when the experimenter just sat silently without making a request for the object, indicates that they did not succeed at the task by simply reacting to the presence of the experimenter. In this condition, infants did not reliably select the object that the requesting experimenter had prior contact with. These findings add to the existing literature by clarifying that infants use others' prior experiences to interpret requests for absent objects.

Study 2

Recall that a critical task infants face when decoding absent reference is determining which category member a speaker is referring to. To do this, they may track others' experiences vis-à-vis referent objects. Because perceptual contact with referents is blocked during absent reference, infants must maintain links between people and objects. One means of doing so is by representing features of objects and linking those sets of object features with particular speakers. In Study 1, for example, infants may have linked the ball features of red and on the right with E1 and blue and on the left with E2. Maintaining these links between speakers and object features may have enabled infants to interpret the ambiguous request. In particular, the experimenter's request for a ball may have led infants to activate their representation of the link between the requesting speaker and the features of the object she interacted with.

Previous research on infants' ability to represent object features over short occlusions suggests that their skills may initially be somewhat limited. First, infants, like adults, can only represent a few object features at a time (e.g., Kaldy & Leslie, 2003; Oakes et al., 2006; Ross-Sheeley et al., 2003). In addition, they seem better able to represent some features over others. Research from diverse domains including toddlers' word learning (e.g., Akhtar & Tomasello, 1996; Smith & Gasser, 2005), early object knowledge (e.g., Tremoulet et al., 2000; Xu & Carey, 1996; Xu et al., 1999), and infants' spatial memory (e.g., Moore & Meltzoff, 2004; Newcombe, Huttenlocher, Drummey, & Wiley, 1998; Newcombe, Huttenlocher, & Learmonth, 1999) suggests that cues to spatial location may be primary.

Xu and colleagues have revealed that infants younger than 10 months rely almost exclusively on spatiotemporal information when tracking moving objects (e.g., Xu & Carey, 1996; Xu et al., 1999). At 10 months and older, however, infants also show sensitivity to cues to object identity. The shift in infants' use of different types of features may be mediated (in part) by an increase in language understanding (Xu, 1999). Because infants' absent reference comprehension is still developing during their second year, it is possible that they may still continue to rely on spatial information to maintain links between speakers and objects. Study 2 investigated this possibility.

The infants in Study 1 were provided with two cues to the location of the absent objects. In particular, the objects were placed in containers matching their color and prior spatial location. To investigate whether stable cues to an object's spatial location facilitated absent reference comprehension, we modified the Study 1 request condition. Infants were tested in two conditions that varied the stability of spatial cues. In one condition, they were offered consistent spatial information alone. In particular, the objects were placed in yellow buckets, instead of the red and blue buckets used in Study 1, and appeared in a set spatial position throughout the session (one bucket appeared on the left and the other appeared on the right). In the other condition, the spatial cue was put in conflict with the color cue, so that consistent spatial information was not offered. In this condition, the objects remained in the colored buckets, but the location of the containers was reversed between the ball introduction and test phases. If consistent spatial cues facilitate infants' absent reference understanding, we expected they would select the correct ball when spatial information was the only cue and have difficulty when they needed to override spatial information to use the color cue.

Method

Participants

Participants were 48 infants ranging in age from 14 months 21 days to 20 months 9 days (*M* age = 16 months 28 days; 24 boys and 24 girls). Infants and their parents were recruited as in Study 1. Six additional infants participated, but their data were excluded because of experimenter error (3) and parental interference (3).

Materials and Equipment

The materials and equipment were the same as in Study 1 except that two yellow buckets were used for the space condition.

Room Setup

A pilot study of the space condition revealed that our room setup for Study 1 was not appropriate for an investigation of infants' use of spatial information. During the object introduction phase of Study 1, parents were seated to the right of the test objects and infants were free to move around. Infants were then placed on their parent's lap for the test phase, and the test objects were lowered to the floor so that they maintained their constant spatial position relative to infants (see Figure 1). Moving the buckets from the cabinets to the floor thus required infants to track objects across spatial translation (because infants were moved onto their parent's lap) and spatial rotation (because the buckets were rotated to the left as they were placed on the floor). In Study 2, the situation was made even more complex by removing the color cue (in the space condition) and asking infants to override spatial information (in the color condition). A pilot study suggested that this additional complexity made the task too difficult for infants. In particular, in a pilot version of the space condition, with parents in the Study 1 positions, only 4 of the 10 infants were able to locate the correct object. For this reason, in Study 2, parents were seated directly across from the file cabinets, thus reducing the complexity by removing the need for rotation. During the test phase, the buckets were lowered to the floor directly in front of the participants (see Figure 3).

Procedure and Design

The design was between subjects. Infants were randomly assigned to the space ($n = 24$) or color ($n = 24$) condition, with the constraint that the ages in the two conditions were matched and equal numbers of boys and girls participated in each condition. All other design features were the same as in Study 1.

The procedure was the same as the request condition in Study 1 with a few modifications that were designed to investigate whether the spatial cue was of primary importance for infants' ability to represent links between speakers and objects.

In the space condition, yellow buckets were used, so that habitual location was the only cue available to infants. In the color condition, the spatial position of the (colored) buckets was reversed when the buckets were placed on the floor during the test phase. For example, if the red bucket had been on the right and the blue bucket had been on the left during the ball introduction phase, during the test phase the red bucket would be placed on the left and the blue bucket would be placed on the right. In the color condition, infants had to overcome information about spatial location to use the color cue.

Coding

Data were coded as in Study 1. A second coder, naive to which experimenter played with which ball, coded 85% of the sessions to determine which ball the infants selected. Excellent reliability between the coders was obtained: They disagreed on only two cases (95% agreement, $\kappa = .90$, $p < .05$).

Results

In Study 2, we investigated whether consistent spatial information facilitated infants' ability to maintain links between speakers and objects across present and absent reference episodes. We first compared the number of infants who selected the correct ball in the space (21 of 24) and color (11 of 24) conditions using a chi-square test of association. The analysis revealed that infants were more likely to select the correct object in the space condition, $\chi^2(1, N = 24) = 9.36$, $p < .05$. To compare infants' responding with chance levels, we used binomial tests. These analyses indicated that only infants in the space condition revealed reliable selection of the target object ($p < .05$). See Figure 4 for a summary of the results.

As in Study 1, post hoc coding was conducted on the experimenters' behavior during the ball introduction phase for the space ($n = 22$) and color ($n = 23$) conditions. The analyses of the number of times the experimenters said the word "ball" and the number of words they used revealed no differences between the space (M ball = 6.68, $SD = 0.78$; M words = 95.66, $SD = 18.78$) and color (M ball = 7.00, $SD = 0.84$; M words = 93.07, $SD = 21.02$) conditions: independent-samples $ts(43) = 1.32$ (ball) and 0.44 (words). In addition, the requester's production of ball and total words (M ball = 6.78, $SD = 0.90$; M words = 95.73, $SD = 27.20$) was equal to that of the nonrequester (M ball = 6.91, $SD = 1.02$; M words = 92.93, $SD = 25.53$): paired-samples $ts(44) = 0.88$ (ball) and 0.54 (words). A coder also made a judgment about which of the experimenters would be the requester based on their behavior during the ball introduction phase. However, the coder only identified the requester 53% of the time (not different from chance by a binomial test). These analyses suggest that the requester was not unwittingly cuing infants to the importance of her interaction.

Coding of the test phase was conducted as in Study 1. In particular, a coder who was naive to which ball the experimenters played with watched the test phase for any signs of explicit cuing to the side of the target and guessed which ball the requester had played with on the basis of her behavior during the test phase. Explicit cuing was rare, occurring on only 17% of the coded trials (7 of 41). Though the cuing was more likely to occur in the space (86% or 6 cues) than color (14% or 1 cue) condition, it was only predictive of target side on 14% of the cued trials (1 trial in the space condition) and only predicted which side the infant went to on 57% of the cued trials (4 trials, 3 in the space condition). This value is not different from chance by a binomial test. Of note, when the trials with explicit cuing were removed from analysis, the

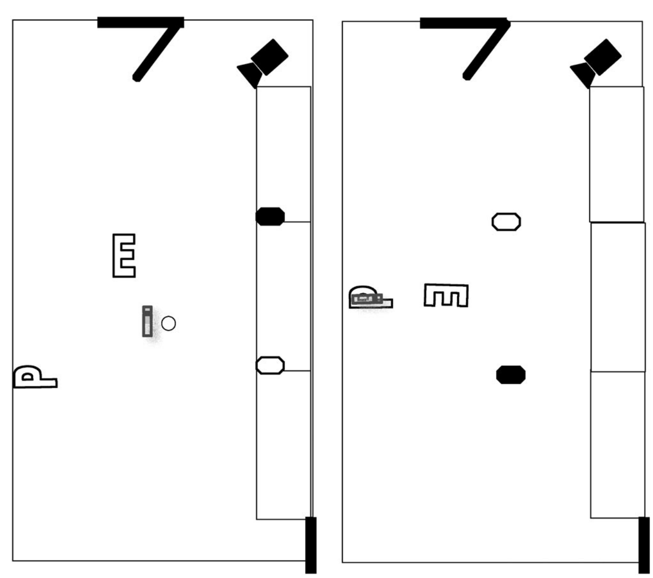

Figure 3. Room setup for Study 2 (color condition) for the ball introduction (left) and the test phase (right). The camera is shown in the top right corner. E = experimenter; P = parent.

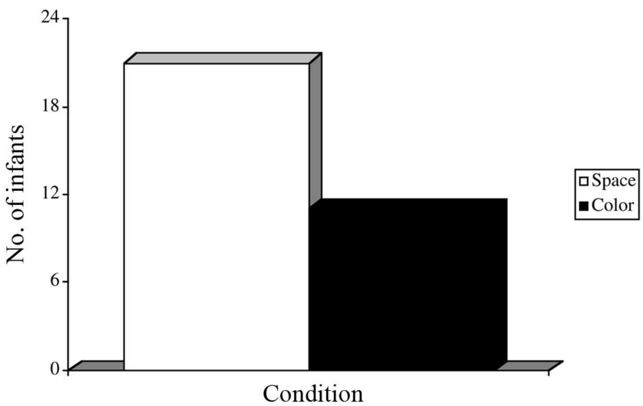

Figure 4. Number of infants selecting the correct object in Study 2 in each condition.

same pattern of findings was obtained: more target selection in the space than color condition and above-chance selection of the target only in the space condition. Hence, explicit cuing on the part of the requester cannot account for the Study 2 findings.

Discussion

In Study 2, we investigated whether stable cues to a referent's spatial location facilitated infants' ability to maintain links between speakers and objects across present and absent reference episodes. Only infants in the condition where consistent spatial information was offered were able to locate the referent of an ambiguous request for an absent object. This finding is consistent with studies of infants' word learning, object knowledge, and spatial memory (e.g., Akhtar & Tomasello, 1996; Newcombe et al., 1999; Smith & Gasser, 2005; Xu & Carey, 1996). In all three domains, infants made robust use of spatial information to identify referents and to track objects. In addition, research from the adult literature suggests that adults will indicate previous locations gesturally (e.g., by pointing to a previously occupied chair) when talking about absent things (e.g., Haviland, 1993, 2000). Together with the current findings, this research indicates that tracking information about spatial position may be of central importance during absent reference.

Research on spatial memory suggests that infants in the current study may have used cue learning and dead reckoning to locate the absent referents (see Newcombe & Huttenlocher, 2000, for a discussion). Previous research has revealed dead reckoning skills early in infancy. In particular, 6-month-olds can recalibrate the position of objects in the world after being rotated in space, and slightly older infants can do so following translation along a linear path (e.g., Landau & Spelke, 1988; Lepecq & Lafaite, 1989; McKenzie, Day, & Ihsen, 1984; Rieser, 1979). In Study 1, infants were subject to both spatial translation (because infants were moved to their parent's lap) and spatial rotation (because the buckets were rotated as they were placed on the floor), yet they still located the correct object. Thus, it is possible that reckoning was a mechanism they recruited to solve the task. However, Study 2 revealed that when the task was made more difficult, by removing either color (in the pilot condition) or spatial information (in the color condition), infants failed to select the correct object. This finding suggests that dead reckoning skills only operated robustly when the task demands were not too great.

Cue learning emerged as a second central mechanism. Previous research on spatial memory has revealed that infants as young as 5 months can use habitual location to find objects (e.g., Newcombe et al., 1999; McDonough, 1999; Rieser, 1979). In Study 2, only infants in the condition where cues to habitual location were offered alone reliably selected the requester's object. This finding suggests that such cues may be of central importance for tracking objects during absent reference. However, the results from the Study 1 request condition (with spatial and color information) and the Study 2 pilot condition (with spatial information alone) suggest that infants may sometimes need other cues to maintain links between speakers and objects. In both conditions, both spatial translation and rotation were necessary for tracking object location. However, only infants in the request condition reliably selected the experimenter's object. This finding indicates that when infants undergo both spatial rotation and translation, other cues to object identity (e.g., color, form, texture) may be necessary to represent links between people and objects. All in all, infants' use of color and spatial information when interpreting absent reference may be somewhat flexible: They use cues to spatial position alone under some circumstances but can also recruit other cues when they must (see Newcombe & Huttenlocher, 2000, for a similar argument).

General Discussion

The current studies investigated two skills that support infants' ability to interpret ambiguous requests for absent objects: tracking others' experiences and representing object features across present and absent reference episodes. The first study demonstrated that 14- to 20-month-old infants tracked others' experiences to interpret such requests. The second study demonstrated that the infants' access to stable cues to an object's spatial location facilitated their ability to maintain links between speakers and objects. Together these studies indicate that infants' emerging social–cognitive and object representation skills may work together to support early comprehension of absent reference.

Tracking Others' Experiences

Infants revealed impressive skills at interpreting others' ambiguous requests for objects: They were given only brief exposure to each experimenter and her object, the requests were ambiguous, and the objects were perceptually unavailable. The requests used in the present study were ambiguous because there were two potential referents available. Infants' ability to select the object the requester had played with suggests that they were not relying on some low-level strategy to interpret the requests (e.g., choose the ball that was most recently seen, that is closest to me physically). Instead, infants used information about others' experiences to interpret such requests. Of note, when no request was offered, as in the Study 1 no-request condition, infants did not reliably select the requester's object. This finding demonstrates that infants were interpreting the request, rather than relying on the mere presence of the requester, to guide their behavior.

Tracking others' experiences is of central importance to interpreting references to absent things. During such references, the information available to infants is the speech being offered and what they know about the speaker. For absent reference to be comprehensible, infants must recognize that the referent is something that is linked to both their and the speaker's experience. Otherwise, they might interpret the references in terms of their own experience. While this may be their strategy early on—anyone's reference to "daddy" may be enough to elicit squeals of delight—over time they may come to recognize that it is the link between their and the speaker's experience that is critical. In the present study, babies just past their first birthday were already considering the speaker's experience.

Establishing Mutual Knowledge

Infants' skill at tracking others' experiences may be a first step in establishing mutual knowledge with others. Mutual knowledge is the recognition that knowledge is shared between speakers and listeners. Though iterative, meta-cognitive models of mutual knowledge ("I know that you know that I know that you know that I know . . .") have been proposed for adults, it is likely that young infants stop at the first level ("I know that you know") because of processing constraints. A similar, noniterative version of knowledge tracking (i.e., shared knowledge) has been proposed for adults' interpretation of what others know (e.g., Clark & Marshall, 1981; Pickering & Garrod, 2004).

Mutual knowledge may be established by tracking copresence between a person and an object by noticing that a person and an object appear in the same space (Clark & Marshall, 1981). Infants in the present study may have tracked copresence to establish mutual knowledge. In the current study, infants had contact with each object, thereby establishing copresence for the self and each object. In contrast, the experimenters only had contact with one object, thereby establishing copresence between each experimenter and one object. Because of their still-emerging understanding of others' mental states (e.g., Montgomery, 1992), it is likely that infants in the current study were probably not making complex inferences about others' knowledge states to establish mutual knowledge. Instead, they may have detected that their experience was aligned with the speaker's via a matching strategy. In particular, they may have aligned their representations of self–object contact and other–object contact to determine which object was familiar to both self and other (see Pickering & Garrod, 2004, for a similar account with adults). This aspect of social–cognitive understanding may be a crucial first step in infants' pragmatic competence.

Questions remain concerning what type of copresence is necessary for infants to interpret ambiguous requests for absent objects. In the current study, infants received two different types of copresence information. First, they interacted with each experimenter and her object for 1 min. Next, they passively viewed each experimenter place her object in an opaque container immediately preceding the request. One question is whether the passive viewing was sufficient for infants to establish copresence between each experimenter and her object. That is, did infants need the interaction at all? Recent research from Moll, Carpenter, and Tomasello (in press) suggests that infants needed the interaction. In that study, infants either interacted with an experimenter and objects or watched an experimenter interacting with objects alone. A new object was introduced out of the experimenter's view. When asked to give the experimenter a toy—with the prediction being that infants would give her the toy she had not played with—only infants in the interaction condition gave her the new object. This finding suggests that passive viewing may not be adequate for infants to build person–experience links. Instead, there is something critical about the social context of interacting with people and objects (see also Moll & Tomasello, 2007).

The Quality of Referents

The referents in the current study were spatially and temporally proximal to the discourse context. This proximity was maintained by keeping the objects inside of opaque containers that infants could see for the duration of the experimental session. One remaining question concerns when infants' representational capacity begins to support comprehension of references to things that are further removed. A recent study suggests that infants at the upper ends of the age range used in our study may be able to comprehend such references. In a study by Ganea and Saylor (in press), infants at 18 months held a completely invisible absent referent in mind over a delay of 2.5 min. This finding suggests that increases in infants' representational capacity may support comprehension of referents that are somewhat removed from the present context toward the middle of infants' second year (for supporting naturalistic evidence, see Huttenlocher, 1974; Sachs, 1983). Future experimenters should investigate when infants begin to appreciate references to absent things at even greater spatial and temporal remove, such as the moon or a distant relative.

A second question concerns infants' ability to learn new information about objects via absent reference. Adults acquire information from others' talk about absent objects all the time: For example, if a woman is told that a friend cut several inches off of her hair, she will not be surprised at the transformation when she next sees her friend. The verbal information will have enabled the woman to update her representation of the friend. A recent study by Ganea, Shutts, Spelke, and Deloache (in press) suggests that infants will be able to update representations of absent things using information offered during absent reference episodes at 22 months. In that study, infants at 19 and 22 months were told that an absent object underwent a transformation (e.g., it became wet). Only infants at 22 months revealed the ability to update their representation of the absent object by selecting the newly damp referent object from an array. This finding suggests that the more complex ability to update representations based on absent reference does not emerge until the end of infants' second year.

Summary

Conversations about absent things move discussions to matters distant, abstract, and hypothetical. For young babies, conversations about the absent are likely about matters less distant—nearby parents, toys, and happenings—but investigating the emergence of such conversations may shed light on infants' skills in other areas. The present studies took this approach by placing absent reference in the context of infants' social–cognitive and object representation skills. This approach places absent reference in contact with several core areas of development and adds clarity to the emergence of a skill that is central to human language and cognition.

References

Akhtar, N., & Tomasello, M. (1996). Two-year-olds learn words for absent objects and actions. *British Journal of Developmental Psychology, 14,* 79–93.

Clark, H. H., & Marshall, C. R. (1981). Definite reference and mutual knowledge. In A. K. Joshi, B. L. Webber, & I. A. Sag (Eds.), *Elements of discourse understanding* (pp. 10–63). New York: Cambridge University Press.

Ganea, P. A. (2005). Contextual factors affect absent reference comprehension in 14-month-olds. *Child Development, 76,* 989–998.

Ganea, P. A., & Saylor, M. M. (in press). Infants' understanding of ambiguous requests: Using previous references to absent objects to clarify a person's request. *Child Development.*

Ganea, P. A., Shutts, K., Spelke, E., & Deloache, J. S. (in press). Thinking of things unseen: Infants' use of new information to update object representations. *Psychological Science.*

Haviland, J. B. (1993). Anchoring, iconicity, and orientation in Guugu Yimithirr pointing gestures. *Journal of Linguistic Anthropology, 3,* 3–45.

Haviland, J. B. (2000). Pointing, gesture spaces, and mental maps. In D. McNeill (Ed.), *Language and gesture* (pp. 13–46). Cambridge, England: Cambridge University Press.

Huttenlocher, J. (1974). The origins of language comprehension. In R. Solso (Ed.), *Theories in cognitive psychology* (pp. 331–368). Hillsdale, NJ: Erlbaum.

Kaldy, Z., & Leslie, A. M. (2003). A memory span of one? Object identification in 6.5-month-old infants. *Cognition, 97,* 153–177.

Keysar, B., Barr, D. J., Balin, J. A., & Brauner, J. S. (2000). Taking perspectives in conversation: The role of mutual knowledge in comprehension. *Psychological Science, 11,* 32–38.

Kuhlmeier, V. A., Wynn, K., & Bloom, P. (2003). Attribution of dispositional states by 12-month-olds. *Psychological Science, 14,* 402–408.

Landau, B., & Spelke, E. (1988). Geometric complexity and object search in infancy, *Developmental Psychology, 24,* 512–521.

Lepecq, J. C., & Lafaite, M. (1989). The early development of position constancy in a non-landmark environment. *British Journal of Developmental Psychology, 7,* 289–306.

Liskowski, U., Carpenter, M., Henning, A., Striano, T., & Tomasello, M. (2004). Twelve-month-olds point to share attention and interest. *Developmental Science, 7,* 297–307.

McDonough, L. (1999). Early declarative memory for location. *British Journal of Developmental Psychology, 17,* 381–402.

McKenzie, B. E., Day, R. H., & Ihsen, E. (1984). Localization of events in space: Young infants are not always egocentric. *British Journal of Developmental Psychology, 2,* 1–9.

Miller, J. F., Chapman, R. S., Branston, M. B., & Reichle, J. (1980). Language comprehension in sensorimotor stages V and VI. *Journal of Speech and Hearing Research, 23,* 284–311.

Moll, H., Carpenter, M., & Tomasello, M. (in press). Fourteen-month-olds know what others experience only in joint engagement with them. *Developmental Science*.

Moll, H., & Tomasello, M. (2007). How 14- and 18-month-olds know what others have experienced. *Developmental Psychology, 43,* 309–317.

Montgomery, D. E. (1992). Young children's theory of knowing: The development of a folk epistemology. *Developmental Review, 12,* 410–430.

Moore, M. K., & Meltzoff, A. N. (2004). Object permanence after a 24-hr delay and leaving the locale of disappearance: The role of memory, space, and identity. *Developmental Psychology, 40,* 606–620.

Newcombe, N. S., & Huttenlocher, J. (2000). *Making space: The development of spatial representation and reasoning.* Cambridge, MA: MIT Press.

Newcombe, N., Huttenlocher, J., Drummey, A. B., & Wiley, J. (1998). The development of spatial location coding: Place learning and dead reckoning in the second and third years. *Cognitive Development, 13,* 185–200.

Newcombe, N., Huttenlocher, J., & Learmonth, A. (1999). Infants' coding of location in continuous space. *Infant Behavior and Development, 22,* 483–510.

Oakes, L. M., Ross-Sheeley, S., & Luck, S. J. (2006). Rapid development of feature binding in visual short-term memory. *Psychological Science, 17,* 781–787.

O'Neill, D. K. (1996). Two-year-old children's sensitivity to a parent's knowledge state when making requests. *Child Development, 67,* 659–677.

Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences, 27,* 169–226.

Rieser, J. J. (1979). Spatial orientation in six-month-old infants. *Child Development, 50,* 1078–1087.

Ross-Sheeley, S., Oakes, L. M., & Luck, S. J. (2003). The development of visual short-term memory. *Child Development, 74,* 1807–1822.

Sachs, J. (1983). Talking about the there and then: The emergence of absent reference in parent–child discourse. In K. E. Nelson (Ed.), *Children's language* (Vol. 4., pp. 1–28). Hillsdale, NJ: Erlbaum.

Saylor, M. M. (2001). *Understanding talk about the absent: An investigation of infants' comprehension of absent reference from 12 to 31 months.* Unpublished doctoral dissertation, University of Oregon.

Saylor, M. M. (2004). 12- and 16-month-old infants recognize properties of mentioned absent things. *Developmental Science, 7,* 599–611.

Saylor, M. M., & Baldwin, D. A. (2004). Discussing those not present: Comprehension of references to absent caregivers. *Journal of Child Language, 31,* 537–560.

Smith, L., & Gasser, M. (2005). The development of embodied cognition: Six lessons from babies. *Artificial Life, 11,* 13–29.

Tomasello, M., & Haberl, K. (2003). Understanding attention: 12- and 18-month-olds know what is new for other persons. *Developmental Psychology, 39,* 906–912.

Tremoulet, P. D., Leslie, A. M., & Hall, D. G. (2000). Infant individuation and identification of objects. *Cognitive Development, 15,* 499–522.

Xu, F. (1999). Object individuation and object identity in infancy: The role of spatiotemporal information, object property information, and language. *Acta Psychologica, 102,* 113–136.

Xu, F., & Carey, S. (1996). Infants' metaphysics: The case of numerical identity. *Cognitive Psychology, 30,* 111–153.

Xu, F., Carey, S., & Welch, J. (1999). Infants' ability to use object kind information for object individuation. *Cognition, 70,* 137–166.

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