CHILD DEVELOPMENT

Child Development, xxxx 2016, Volume 00, Number 0, Pages 1–9

Out of Reach, Out of Mind? Infants' Comprehension of References to Hidden Inaccessible Objects

Maria A. Osina and Megan M. Saylor
Vanderbilt University

Patricia A. Ganea
University of Toronto

This study investigated the nature of infants' difficulty understanding references to hidden inaccessible objects. Twelve-month-old infants (N = 32) responded to the mention of objects by looking at, pointing at, or approaching them when the referents were visible or accessible, but not when they were hidden and inaccessible (Experiment I). Twelve-month-olds (N = 16) responded robustly when a container with the hidden referent was moved from a previously inaccessible position to an accessible position before the request, but failed to respond when the reverse occurred (Experiment II). This suggests that infants might be able to track the hidden object's dislocations and update its accessibility as it changes. Knowing the hidden object is currently inaccessible inhibits their responding. Older, 16-month-old (N = 17) infants' performance was not affected by object accessibility.

Although infants are tuned to language from the earliest stages of development (e.g., May, Byers-Heinlein, Gervain, & Werker, 2011), the ability to use language to guide their behavior develops gradually across the 1st year. As one example, it is not until around 12 months of age that infants engage in search behaviors in response to verbal prompts about absent toys. At this point, they can turn around to locate a familiar object in a stable location (Huttenlocher, 1974), or approach it and bring it in response to an experimenter's request (Osina, Saylor, & Ganea, 2013; Saylor, Ganea, & Vázquez, 2011). However, the location of referents relative to the infant affects whether they respond to requests to locate hidden toys (Ganea, 2005). In the current research, we investigate how infants' spatial and object representations affect their responses to inaccessible referents.

Research shows that object and spatial representations are strongly linked in infants' minds (e.g., Benitez & Smith, 2012; Carey & Xu, 2001). Infants as young as 6 months can form complex audio–visual–spatial representations where objects, their locations, and characteristic sounds are associated with each other (Kirkham, Richardson, Wu, & Johnson, 2012; Richardson & Kirkham, 2004). For example, in the study by Richardson and Kirkham (2004), 6-month-old infants were presented with pictures of two toys, each in its separate port on the computer screen. Each toy produced a distinct sound. After several presentations, infants heard a sound while the toy was not on the screen. Infants fixated at the associated critical location associated with the toy and its sound. Kirkham et al. (2012) also showed that 3- and 6-month-old infants could learn a sound–location association only when two featurally distinct toys were coupled with two different sounds in each of the two locations. However, when two identical toys or six different toys were coupled with the sound presentation in each location only older, 10-month-old infants could learn the association. This suggests that featural information of the indexing object is an important element of audio–visual–spatial associations.

Low-level object–location associations that are available to very young infants support older infants' understanding of others' attention and communicative intentions. Infants can use a person's attention to a specific location as a source of information about an object. For example, around 12 months, infants can follow an adult's line of regard to infer the presence of an invisible object

We thank Dr. Daniel Levin and Dr. Amy Needham for helpful advice and suggestions regarding this research. We thank Carly Mecl, Lydia Fuller, Courtney Foulk, Madison Hatfield, and Erica Bernstein for their help with collecting data and coding. We thank all the families who participated.

Correspondence concerning this article should be addressed to Maria A. Osina, Department of Psychology and Human Development, Vanderbilt University, Peabody #552, 230 Appleton Place, Nashville, TN 37203. Electronic mail may be sent to maria.a.osina@vanderbilt.edu.

DOI: 10.1111/cdev.12656

(Behne, Liszkowski, Carpenter, & Tomasello, 2012; Gliga & Csibra, 2009). Infants can do so even when the final destination of the adult's gaze is occluded from their view (Csibra & Volein, 2008; Moll & Tomasello, 2004). This suggests infants' understanding that a person is attending to an object, not to an empty space.

The relationship between objects and their locations can be used in a symbolic way to support communication about the absent (Liszkowski & Ramenzoni, 2015). From as early as 12 months, infants begin to realize that empty locations can be used as symbols that stand for the objects that previously occupied those locations, and interpret pointing to empty locations as an invitation to join attention on an absent object. For example, in several studies infants pointed at an object's empty location to request that object from an adult or to draw the adult's attention to it (Bohn, Call, & Tomasello, 2015; Liszkowski, Carpenter, & Tomasello, 2007; Liszkowski, Schäfer, Carpenter, & Tomasello, 2009). In Liszkowski and Ramenzoni (2015), infants identified the right object in a set of objects in response to an adult's pointing to the target object's prior location. Butcher, Mylander, and Goldin-Meadow (1991) report that a deaf child often pointed at the location associated with an absent entity to communicate about that entity. For example, pointing at the dad's chair served as a reference to the absent dad, and pointing at the corner where they usually put a Christmas tree helped convey something about celebrating Christmas. Infants can also use associations between objects and locations to learn absent objects' names. Thus, in Samuelson, Smith, Perry, and Spencer (2011), 16- to 18-month-old infants inferred the name of an absent object when their attention was directed to the previous location of that object.

Altogether, this research demonstrates that object–location associations are important and informative to infants, and infants rely on them in understanding other people and communicating with them. At the same time, some properties of locations that seem irrelevant for communication can be very disruptive. One such property is the stability of an object's location. Infants' ability to learn new words is disrupted if referent objects appear in different places during each presentation (Benitez & Smith, 2012). Infants have difficulty selecting the object that the experimenter had previously played with when before the test the target's location is swapped with the distractor's location (Saylor & Ganea, 2007). If an object previously appeared in two locations, pointing to its last location did not cue 18-month-old infants to attend to that object among other objects (Liszkowski & Ramenzoni, 2015). Seeing an object before the study in one or many nontest locations also interferes with infants' ability to respond to that object's name when it is hidden in the test room (Osina et al., 2013). Location information has a disruptive effect at older ages as well, when children have to use language to update an object's representation. Recent studies have shown that although children as young as 19 months can use language to update a change in object properties (Galazka & Ganea, 2014), it is not until after 2.5 years of age that children can demonstrate this ability when an object's prior location is changed (Ganea & Harris, 2010, 2013).

Another characteristic of the object location that affects infants' responding to talk about a hidden object is its accessibility. Research suggests that infants begin to understand talk about absent things around their first birthday (Ganea & Saylor, 2013a, 2013b; Huttenlocher, 1974). When hearing labels of out of view objects infants turn around to look at the referent (Huttenlocher, 1974) or initiate search for it (Gallerani, Saylor, & Adwar, 2009; Saylor, 2004). Initially, infants' comprehension is constrained by referent proximity and accessibility. Infants only respond to names of most proximal (close in space) and accessible (easy to get) objects, and as they get older, their comprehension spreads to remote and inaccessible objects (Saylor, 2004). For example, at 11 months, infants will look at a mentioned toy that is close to them (Huttenlocher, 1974). At 14 months, infants search for a mentioned object if it is easily accessible (a toy in a basket), but are unlikely to do so when the object is not easily accessible (a toy in the basket behind a couch; Ganea, 2005). After 16 months, infants' comprehension extends to objects located in a different room (Huttenlocher, 1974).

There are several possibilities why infants have more difficulty responding to inaccessible than accessible objects. First, in previous studies, inaccessible locations (containers that occlude referent objects from view) were both further away from infants and themselves occluded from infants' direct view by furniture or walls (Ganea, 2005; Huttenlocher, 1974). Occluding containers with referent objects from infants' direct view not only makes the referents less accessible motorically, but also makes their hiding locations not immediately available for such nonverbal responses as looking and pointing. Therefore, infants may fail to respond to names of inaccessible objects by looking, pointing, or approaching them not only because they were difficult to access, but also because testing situations did not afford looking and pointing toward the target locations. In other words, object accessibility was confounded with distance and with the visibility of the object hiding locations. In Experiment I, we isolated accessibility from distance and the occlusion of the hiding locations by comparing infants' performance with objects hidden within infants' reach (accessible) and with objects hidden too high for infants to reach (inaccessible). Hiding locations were at similar distances to the infants and in their direct view. If accessibility affects responding independently of distance and occlusion, infants should be less likely to respond to inaccessible than accessible objects.

Although in our design both accessible and inaccessible locations were in infants' direct view, it could still be more difficult for infants to respond to inaccessible objects not for representational reasons, but because it takes more effort to look or point above one's head than straight ahead. To control for this possibility, we compared infants' responses to accessible and inaccessible objects when they remained visible and when they were hidden. If infants fail to respond to inaccessible objects because it is more effortful, they should not respond to names of visible, but inaccessible objects.

Another possibility is that infants *forget* about objects that are put out of reach and out of view, and their inability to bring referent representations to mind might explain their lack of responding. To address this possibility, in Experiment II, we manipulated whether objects were hidden in an inaccessible location and then made accessible at test, or the reverse. If infants completely forget about objects hidden out of reach, they should not respond when previously inaccessible objects are made accessible, because any representation of the object would have been effectively wiped from memory once the object was made inaccessible. Alternatively, if infants do not forget about objects hidden out of reach, but represent and track their accessibility status as it changes, they should respond when previously inaccessible objects are moved to an accessible position, but not when the reverse occurs. We included two age groups in this experiment—12- and 16-month-olds—to investigate the developmental scope of infants' difficulty with absent inaccessible objects. In previous research, infants of 15–16 months of age were the youngest to show robust comprehension of absent reference to familiar people far away at the time of test (Saylor & Baldwin, 2004) and to objects either not immediately accessible (Saylor, 2004) or hidden in locations occluded by furniture and walls (Huttenlocher, 1974). Therefore, we expected to see a better performance in 16-month-olds than in 12-month-olds.

Experiment I

Method

Participants

Participants were thirty-five 12-month-old infants (M = 12 months 10 days; range = 11;20–13;00, 16 girls). Three infants were omitted because of distraction (2) and experimenter error (1) resulting in the final sample of 32 (16 infants in each condition). Participants for this and all subsequent studies were primarily Caucasian and from middle-class families. They were recruited from a database of families in the southeastern United States and were full-term at birth, normally developing and hearing, with English as their primary language. Data collection took place in the years 2012–2014.

Materials

Target objects were stuffed animals with familiar labels (e.g., a dog, a bear, a frog, a sheep, and a pig). For each infant two stuffed animals were chosen based on the parent report of words "known best." Which toy was used in the *accessible* and *inaccessible* conditions was roughly counterbalanced. Two ottomans identical in shape and size (one brown, one black) were used as target objects' locations. The target objects were put either inside (*occluded object* condition) or in front of an ottoman (*visible object* condition).

Procedure

To avoid cuing infants' behavior, before the study parents were instructed not to interact with their child and not to encourage the child to do anything. There were three phases: *play*, *time delay*, and *test*. The purpose of the minute long *play* phase was to give participants experience with the stimulus object and its label. The experimenter mentioned a toy eight times using infant appropriate speech (e.g., "Look, it's a dog! Do you like dogs? I like dogs!"). Infants were free to move around the room and to handle the toy. At the end of the play phase, infants sat on their parent's lap. The experimenter clapped her hands and called the infant's name to attract his or her attention, and then put the toy away saying, "Look! It's going right here! Bye!" The toy was put inside the ottoman in the occluded object condition and in front of the ottoman in the visible object condition.

The purpose of the *time delay* phase (40 s) was to divert infants' attention from the toy's location so that they would not react reflexively to the researcher's request in the test phase. The experimenter sang, "Twinkle, Twinkle, Little Star" and pointed away from the ottoman.

The *test* phase probed infants' ability to respond to the hidden toy's name. After attracting the infant's attention, the experimenter asked about the toy eight times, first in a hint-like manner to avoid automatic search behaviors to "where" questions (e.g., "What about the dog? Have you seen the dog?"), and then directly (e.g., "Where is the dog? Could you find the dog?"). If infants looked and/or pointed at the toy or its hiding location, the researcher continued with the prompts. If infants approached the toy or the ottoman at any time, the researcher stopped talking, because infants had terminated the test session naturally. With rare exceptions, infants responded to the hint-like requests.

The experimenter gave the toy back to the infant at the end of the test phase or when the infant approached it, and allowed the infant to play with it while she took the ottoman out of the room and brought the other one in. This was done to avoid greater familiarity with the ottoman during the following trial. The procedure was then repeated with the other object.

Design

Object accessibility was manipulated within participants. In the inaccessible condition, an ottoman was positioned on one of the cabinets in the right and left corners of the room (Figure 1). The ottoman was visible but not accessible motorically and placed higher than eye level (3 feet off the ground and 9.3 feet away from the infant). In the accessible condition, the ottoman was on the floor in front of one of the cabinets 7.6 feet away from the infant. The ottoman was thus both visually and motorically accessible. Each infant was tested once in each of these conditions. The order of the conditions and the side of the ottoman were counterbalanced.

Object visibility was manipulated between participants. In the occluded object condition, a toy was hidden inside an ottoman and was not visible to the infant during the delay and test phases. In the visible object condition, a toy was put in front of the ottoman and remained visible during the delay and test.

Coding

Infants' ability to respond to the experimenter's verbal prompts was measured by whether they looked at, pointed at, or approached the toy or its hiding location. If infants showed any of these behaviors they were given a score of 1, otherwise a score of 0.

In this and all subsequent studies, the initial judgments about infants' responses were made by the experimenter during the study and recorded after verifying them on video. A look was coded if infants looked at the toy or the ottoman (if the toy was hidden) following the mention of the toy's name. A point was coded if infants looked and raised their arm in the direction of the toy (ottoman). Approaching the toy (ottoman) was coded if the infant looked at the toy (ottoman) and moved their body toward it. Videotapes of the sessions (58%) were coded by a second coder who was blind to the hypothesis of the study. The coder could see the ottoman because it was partially visible on the tapes, but not the toy in the visible object condition.

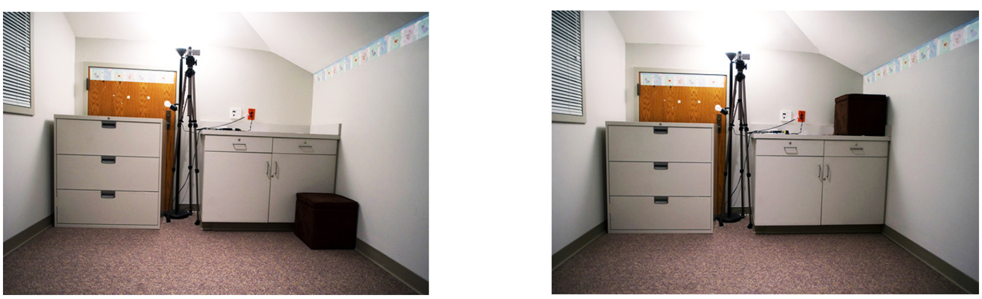

Figure 1. Accessible and inaccessible object locations. [Color figure can be viewed at wileyonlinelibrary.com].

Overall agreement on the presence or absence of target behaviors was high (95%, Cohen's κ = .87). Four disagreements occurred due to the camera position (infants' face was not on camera which prevented the coder from seeing all of the infants' behavior). The experimenter's initial judgments were used in the analyses below.

Additionally, to test if infants' responding was biased by the experimenter's behavior a naïve coder watched the experimenter perform the request during the test phase (40% of all trials) and tried to guess the position (right/left) of the ottoman. The coder correctly guessed on 38.5% of the coded trials which is not different from chance (binomial test, $p = .13$). This suggests that infants were not cued by the experimenter.

Results and Discussion

This experiment investigates the role of object visibility and accessibility in infants' responding to familiar objects' names when both accessible and inaccessible locations were in the infants' direct visual field. If object accessibility matters independently from distance and not because infants have difficulty looking or pointing above their head, infants should be the least responsive when objects were occluded and inaccessible.

The effects of referent visibility and accessibility on infants' responding to the experimenter's reference were analyzed using generalized estimating equations (GEEs), a type of analysis that accounts for correlation between repeated binary measures (Hardin, 2005). Other developmental work reporting the same analysis is Ganea and Harris (2013) and Kretch, Franchak, and Adolph (2014). The presence or absence of infants' responding was modeled using probit regression. Our predictions were confirmed (Figure 2). A significant interaction ($B_2 = 1.44$, $\chi^2_{(1)} = 5.92$; $p < .05$, 95% CI [0.28, 2.6]) indicated that the difference in infants' responses to accessible and inaccessible objects varied according to whether the object was visible or occluded. In the visible object condition, infants responded both, when the referent was accessible (93.8%) and when it was inaccessible (87.5%, $B_1 = -0.384$, $\chi^2_{(1)} = 1.104$, $p = .29$, 95% CI [−1.10, 0.33]). However, in the occluded object condition, 87.5% of the infants responded when the object was accessible, while only 25% of them responded when the object was inaccessible ($B_1 = -1.82$; $\chi^2_{(1)} = 15.3$; $p < .0001$, 95% CI [−2.74, −0.91]). The analysis of the types of infants' responding indicated that they most often looked at the right location, sometimes they approached it, but pointing was rare (see Figure 3). The patterns of responding were similar in all conditions except for occluded inaccessible object condition where only three infants looked and one infant looked and pointed.

These results suggest that infants have difficulty responding to inaccessible occluded objects even when the referents' hiding locations are in infants' direct view and are at a similar distance to the infants as accessible objects. Infants' poor performance with inaccessible objects is not due to their difficulty looking or pointing above eye level. If this were the case infants would not have responded to inaccessible, but visible objects. Rather, infants fail to respond when they have to rely on their representation of the occluded referent and they tag the referent as inaccessible.

There are two possibilities for why infants fail to respond to inaccessible occluded objects. First, infants may forget about objects if they are hidden out of reach and are unable to access the target representation later after the delay phase. Alternatively, infants do not forget about hidden inaccessible objects beyond retrieval. Rather, they can bring to mind information about object accessibility at test, and knowing they cannot currently

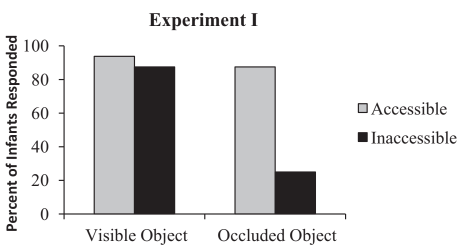

Figure 2. Percent of 12-month-old infants engaging in target behaviors toward the mentioned object in Experiment I.

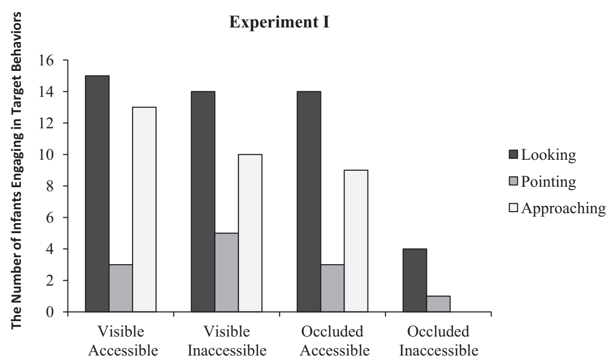

Figure 3. The number of 12-month-old infants engaging in each type of target behaviors: looking, pointing, and approaching the target location.

access the object inhibits their responding. In the next experiment, we investigate these two possibilities. We manipulate when the object becomes inaccessible—at the end of the play phase when the object is hidden or at the test phase immediately prior to the request. If infants forget about objects once they are put out of reach they should not respond when a previously inaccessible object is made accessible during test. Alternatively, if infants can track and update a hidden object's accessibility and bring to mind the object's accessibility status at test infants should respond when a previously inaccessible object is moved to an accessible position and fail to respond when the reverse occurs. We also compare 12- to 16-month-old infants to investigate the developmental scope of this difficulty. We predicted that 16-month-olds would perform better than 12-month-olds as in previous research they were able to show generally more robust comprehension of absent reference than 12-month-olds (Saylor, 2004; Saylor & Baldwin, 2004). Additionally, they were able to show comprehension for referents hidden in a different room and occluded by pieces of furniture (Huttenlocher, 1974).

Experiment II

Method

Participants

Participants were sixteen 12-month-olds (*M* = 12 months 12 days; range = 11;26–12;25, 7 girls) and seventeen 16-month-olds (*M* = 16 months 3 days; range = 15;01–18;20, 8 girls).

Materials, Procedure, Design, and Coding

The same materials, design, and coding as in Experiment I, occluded object condition were used. The following changes were made to the procedure. Each infant participated in two conditions: *inaccessible-to-accessible* and *accessible-to-inaccessible*. In the first condition, the object was hidden in an ottoman that was initially on a cabinet (inaccessible). At the end of the *delay* phase, after singing "Twinkle, Twinkle, Little Star," the experimenter said, "Now I want to bring it here" and moved the ottoman from the cabinet to the floor in front of it (the same position as in the accessible object condition in Experiment I). Then she pointed away to distract infants from the ottoman. The test phase followed. In this condition, the object has been inaccessible the entire time from the moment it was hidden until the test phase.

In the accessible-to-inaccessible condition, everything was the same except that the ottoman was initially on the floor in front of a cabinet and it was moved on top of the cabinet right before the request. In this condition the object has been accessible the entire time except for the test phase.

The order of the conditions and left–right position of the ottoman were counterbalanced.

Results and Discussion

The purpose of this experiment was to investigate whether infants' difficulty responding to hidden inaccessible objects is due to forgetting about them or due to keeping track of object accessibility, and to explore the emergence of these effects across two age groups. A GEE model was run predicting the presence or absence of infants' responses from age, condition, and their interaction. The dependent variable was modeled using probit regression. In the older group, 82.4% of the infants responded in the inaccessible-to-accessible condition and 94.12% of them responded in the accessible-to-inaccessible condition ($B_1 = 0.64$, $\chi^2_{(1)} = 2.29$, $p = .13$, 95% CI [−0.19, 1.46]; see Figure 4). A significant interaction ($B_2 = 2.33$, $\chi^2_{(1)} = 12.11$, $p < .001$, 95% CI [1.02, 3.64]) indicated that the difference in infants' performance in the two conditions was larger in the 12-month-old group than in the 16-month-old group. While 93.8% of 12-month-olds responded in the inaccessible-to-accessible condition, significantly fewer of them (43.75%) responded in the accessible-to-inaccessible condition ($B_1 = -1.69$, $\chi^2_{(1)} = 10.57$, $p < .01$, 95% CI [−2.71, −0.67]). The analysis of the types of infants' responding (see Figure 5) indicated that older infants engaged in looking, pointing, and approaching behaviors in similar ways in both conditions. Twelve-month-old infants in the inaccessible-to-accessible condition engaged in looking and approaching as frequent as 16-month-olds. However, they pointed less often than the older infants (2 instances vs. 8, exact test on proportions, $p = .05$).

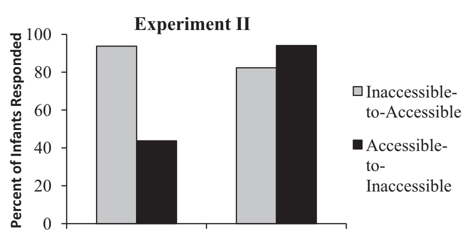

Figure 4. Percent of infants engaging in target behaviors toward the mentioned object in Experiment II.

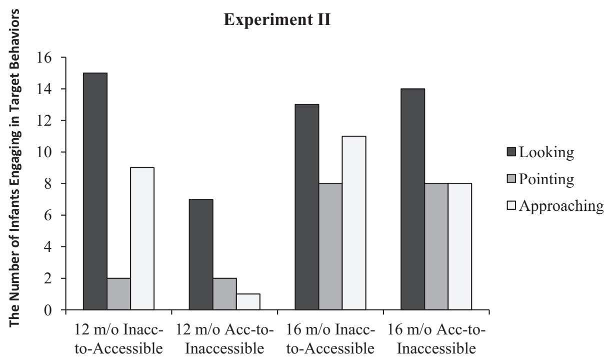

Figure 5. The number of 12- and 16-month-old infants engaging in each type of target behaviors: looking, pointing, and approaching the target location.

Younger infants' performance in the inaccessible-to-accessible condition suggests that they do not forget about hidden inaccessible objects beyond retrieval and can still bring their representations to mind if objects are made accessible at the test phase. This requires that infants track the hidden object's location and update its accessibility status. Infants' poor responding in the accessible-to-inaccessible condition rules out a possibility that infants responded in the inaccessible-to-accessible condition because the researcher reminded them of the object by moving the ottoman before the request. Older infants were not affected by object accessibility and responded in both conditions.

General Discussion

The purpose of the current research was to investigate the source of infants' difficulty responding to names of hidden inaccessible objects. Our findings indicate that 12-month-old infants are less likely to respond to inaccessible than accessible hidden objects even when the objects' hiding locations are directly available for looking and pointing (Experiment I). Infants' encoding of an object as inaccessible does not lead to forgetting about it. Rather, infants can track and update a hidden object's accessibility as it changes, and they can still respond to a name of a previously inaccessible object if it is made accessible at test. At the same time, understanding that an object is made inaccessible inhibits their ability to respond to its name (Experiment II). Older, 16-month-old infants' responding was not affected by referent accessibility.

Although 12-month-old infants' performance in the inaccessible-to-accessible condition suggests that they can track hidden objects' dislocations and can still bring the object to mind after it had been inaccessible for some time, there are several possibilities why infants failed to respond in the accessible-to-inaccessible condition. One possibility is that infants were affected by the unusual pragmatics of this condition. The experimenter is asking them about a toy that she has just put out of their reach. Infants may fail to respond because they know that the toy is now inaccessible and do not understand what the experimenter wants them to do. Supporting evidence for this possibility comes from the article by Topál, Gergely, Miklósi, Erdőhegyi, and Csibra (2008) showing that infants' interpretation of the pragmatics of the testing situation influences their ability to display target knowledge in experimental tasks. In the context of the current experiment, the explanation that infants fail because of unusual pragmatics does not exclude the influence of accessibility on their performance, because infants' understanding of the pragmatic aspect of the test phase depends on their understanding of object accessibility. That is, if infants did not understand that the object was inaccessible they would not have viewed this situation as pragmatically awkward.

Infants' ability to bring to mind information about referent accessibility at the time of the request resembles some findings in adults' language processing. It has been shown that adults' linguistically triggered images of referents may include information about the nature of potential interactions with them (Glenberg et al., 2009). This may include the situation-specific shape of an object and its orientation (Borghi & Riggio, 2009; Zwaan, Stanfield, & Yaxley, 2002), as well as the implied distance to and the accessibility of the object (Borghi, Glenberg, & Kaschak, 2004). For example, in Borghi et al. (2004), after hearing "You are driving the car" participants recognized a more proximally represented "steering wheel" faster than a more distal "back seat." While a greater imagined distance to the referent slowed down adults' reaction times, tagging an object as inaccessible lead to almost no response at all in infants.

Finally, it is also possible that younger infants failed to respond in the accessible-to-inaccessible condition because they could not retrieve representations of inaccessible objects *at all*, even though the objects had been inaccessible for only a few seconds. This seems unlikely, as we would have expected to see a similar failure in the inaccessible-to-accessible condition. To put it another way, it is unlikely that infants in the inaccessible-to-accessible condition could activate a representation of an inaccessible object after the delay and update its location after it was moved while they were unable to engage in similar memory processing in the accessible-to-inaccessible condition. Therefore, we favor the explanation that infants understood that the target object was inaccessible at the time of the request, and this inhibited their responding.

Being fundamentally motor in nature, representing an object as accessible or inaccessible should depend on each infant's individual level of motor development. Another exciting direction for future research could be relating infants' individual differences in motor ability to comprehending absent reference with varying degrees of referent accessibility.

As suggested by the Experiment II, infants can follow hidden objects' dislocations. This finding is consistent with previous object tracking studies showing that infants as young as 6 months can follow objects behind occluders (e.g., Aguiar & Baillargeon, 1999; Bower, Broughton, & Moore, 1971; Gredebäck & Hofsten, 2004; Jonsson & Von Hofsten, 2003). For example, in Jonsson and Von Hofsten (2003), 6-month-old infants watched an object go behind a screen and then looked at the other side of the screen where they anticipated the object to reappear. The current findings show that infants not only follow hidden objects' dislocations, but also track objects' accessibility, and this affects their ability to respond to the objects' names.

In Experiment II, 16-month-olds' ability to respond to names of hidden objects was not affected by accessibility. There are several possible explanations of 16-month-olds' better performance. First, older infants have stronger representational and memory capacity than younger infants, and this could have supported their ability to respond to an object represented as inaccessible. Second, older infants have a more advanced understanding of the intentionality of linguistic reference (absent reference is an invitation to join attention on a nonvisible object), and this might enable them to respond despite knowing that the object is not accessible. Finally, 16-month-olds are on average taller and more mobile than 12-month-olds (most of them walk), and the inaccessible location could look more approachable to them than to younger infants. Which possibility is right is an interesting question for future research.

Altogether, the current research suggests that object accessibility plays an important role in infants' ability to respond to an adult's reference to that object when it is hidden. Infants have a strong tendency to look, point, or approach a hidden toy if its hiding location is accessible and do not engage in such behaviors when it is out of reach. Infants do not forget about hidden out-of-reach objects. Rather, they track and update hidden objects' dislocations and bring to mind information about their accessibility at the time of request. Knowing that the object is not currently accessible inhibits younger infants' responding, but only 4 months later infants no longer show this effect.

References

Aguiar, A., & Baillargeon, R. (1999). 2.5-month-old infants' reasoning about when objects should and should not be occluded. *Cognitive Psychology*, *39*, 116–157. doi:10.1006/cogp.1999.0717.

Behne, T., Liszkowski, U., Carpenter, M., & Tomasello, M. (2012). Twelve-month-olds' comprehension and production of pointing. *British Journal of Developmental Psychology*, *30*, 359–375. doi:10.1080/00221325.1979.10533420.

Benitez, V. L., & Smith, L. B. (2012). Predictable locations aid early object name learning. *Cognition*, *125*, 339–352. doi:10.1016/j.cognition.2012.08.006.

Bohn, M., Call, J., & Tomasello, M. (2015). Communication about absent entities in great apes and human infants. *Cognition*, *145*, 63–72. doi:10.1016/j.cognition.2015.08.009.

Borghi, A. M., Glenberg, A. M., & Kaschak, M. P. (2004). Putting words in perspective. *Memory & Cognition*, *32*, 863–873. doi:10.3758/BF03196865.

Borghi, A. M., & Riggio, L. (2009). Sentence comprehension and simulation of object temporary, canonical and stable affordances. *Brain Research*, *1253*, 117–128. doi:10.1016/j.brainres.2008.11.064.

Bower, T. G. R., Broughton, J. M., & Moore, M. K. (1971). Development of the object concept as manifested in the tracking behavior of infants between 7 and 20 weeks of age. *Journal of Experimental Child Psychology*, *11*, 182–193. doi:10.1016/0022-0965(71)90074-9.

Butcher, C., Mylander, C., & Goldin-Meadow, S. (1991). Displaced communication in a self-styled gesture system: Pointing at the nonpresent. *Cognitive Development*, *6*, 315–342. doi:10.1016/0885-2014(91)90042-C.

Carey, S., & Xu, F. (2001). Infants' knowledge of objects: Beyond object files and object tracking. *Cognition*, *80*, 179–213. doi:10.1016/S0010-0277(00)00154-2.

Csibra, G., & Volein, A. (2008). Infants can infer the presence of hidden objects from referential gaze information. *British Journal of Developmental Psychology*, *26*(1), 1–11. doi:10.1348/026151007X185987.

Galazka, M. A., & Ganea, P. A. (2014). The role of representational strength in verbal updating: Evidence from 19-and 24-month-olds. *Journal of Experimental Child Psychology*, *121*, 156–168. doi:10.1016/j.jecp.2013.12.002.

Gallerani, C. M., Saylor, M. M., & Adwar, S. (2009). Mother–infant conversation about absent things. *Language Learning and Development*, *5*, 282–293. doi:10.1080/15475440902897604.

Ganea, P. A. (2005). Contextual factors affect absent reference comprehension in 14-month-olds. *Child Development*, *76*, 989–998. doi:10.1111/j.1467-8624.2005.00892.x.

Ganea, P. A., & Harris, P. L. (2010). Not doing what you are told: Early perseverative errors in updating mental representations via language. *Child Development*, *81*, 457–463. doi:10.1111/j.1467-8624.2009.01406.x

Ganea, P. A., & Harris, P. L. (2013). Early limits on the verbal updating of an object's location. *Journal of Experimental Child Psychology*, *114*, 89–101. doi:10.1016/j.jecp.2012.04.013.

Ganea, P. A., & Saylor, M. M. (2013a). Talking about the near and dear: Infants' comprehension of displaced speech. *Developmental Psychology*, *49*, 1299. doi:10.1037/a0030086.

Ganea, P. A., & Saylor, M. M. (2013b). Representational constraints on language development: Thinking and learning about absent things. *Child Development Perspectives*, *7*, 227–231. doi:10.1111/cdep.12045.

Glenberg, A. M., Becker, R., Klötzer, S., Kolanko, L., Müller, S., & Rinck, M. (2009). Episodic affordances contribute to language comprehension. *Language and Cognition*, *1*, 113–135. doi:10.1515/LANGCOG.2009.006.

Gliga, T., & Csibra, G. (2009). One-year-old infants appreciate the referential nature of deictic gestures and words. *Psychological Science*, *20*, 347–353. doi:10.1111/j.1467-9280.2009.02295.x

Gredebäck, G., & Hofsten, C. (2004). Infants' evolving representations of object motion during occlusion: A longitudinal study of 6-to 12-month-old infants. *Infancy*, *6*, 165–184. doi:10.1207/s15327078in0602_2.

Hardin, J. W. (2003). *Generalized estimating equations (GEE)*. Hoboken, NJ: Wiley.

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

Jonsson, B., & Von Hofsten, C. (2003). Infants' ability to track and reach for temporarily occluded objects. *Developmental Science*, *6*, 86–99. doi:10.1111/1467-7687.00258.

Kretch, K. S., Franchak, J. M., & Adolph, K. E. (2014). Crawling and walking infants see the world differently. *Child Development*, *85*, 1503–1518. doi:10.1111/cdev.12206.

Kirkham, N. Z., Richardson, D. C., Wu, R., & Johnson, S. P. (2012). The importance of "what": Infants use featural information to index events. *Journal of Experimental Child Psychology*, *113*, 430–439.

Liszkowski, U., Carpenter, M., & Tomasello, M. (2007). Pointing out new news, old news, and absent referents at 12 months of age. *Developmental Science*, *10*, F1–F7. doi:10.1016/j.jecp.2012.07.001.

Liszkowski, U., Schäfer, M., Carpenter, M., & Tomasello, M. (2009). Prelinguistic infants, but not chimpanzees, communicate about absent entities. *Psychological Science*, *20*, 654–660.

Liszkowski, U., & Ramenzoni, V. C. (2015). Pointing to nothing? Empty places prime infants' attention to absent objects. *Infancy*, *20*, 433–444. doi:10.1111/j.1467-9280.2009.02346.x.

May, L., Byers-Heinlein, K., Gervain, J., & Werker, J. F. (2011). Language and the newborn brain: does prenatal language experience shape the neonate neural response to speech? *Frontiers in Psychology*, *2*, 26–34. doi:10.3389/fpsyg.2011.00222.

Moll, H., & Tomasello, M. (2004). 12-and 18-month-old infants follow gaze to spaces behind barriers. *Developmental Science*, *7*(1), F1–F9. doi:10.1111/j.1467-7687.2004.00315.x.

Osina, M. A., Saylor, M. M., & Ganea, P. A. (2013). When familiar is not better: 12-month-old infants respond to talk about absent objects. *Developmental Psychology*, *49*, 138. doi:10.1037/a0027903.

Richardson, D. C., & Kirkham, N. Z. (2004). Multi-modal events and moving locations: Eye movements of adults and 6-month-olds reveal dynamic spatial indexing. *Journal of Experimental Psychology: General*, *133*, 46–62. doi:10.1037/0096-3445.133.1.46.

Samuelson, L. K., Smith, L. B., Perry, L. K., & Spencer, J. P. (2011). Grounding word learning in space. *PLoS ONE*, *6*, e28095. doi:10.1371/journal.pone.0028095.

Saylor, M. M. (2004). 12- and 16-month-old infants recognize properties of mentioned absent things. *Developmental Science*, *7*, 599–611. doi:10.1111/j.1467-7687.2004.00383.x.

Saylor, M. M., & Baldwin, D. A. (2004). Discussing those not present: Comprehension of references to absent caregivers. *Journal of Child Language*, *31*, 537–560. doi:10.1017/S0305000904006282.

Saylor, M. M., & Ganea, P. (2007). Infants interpret ambiguous requests for absent objects. *Developmental Psychology*, *43*, 696. doi:10.1037/0012-1649.43.3.696.

Saylor, M. M., Ganea, P. A., & Vázquez, M. D. (2011). What's mine is mine: twelve-month-olds use possessive pronouns to identify referents. *Developmental Science*, *14*, 859–864. doi:10.1111/j.1467-7687.2010.01034.x.

Topál, J., Gergely, G., Miklósi, Á., Erdőhegyi, Á., & Csibra, G. (2008). Infants' perseverative search errors are induced by pragmatic misinterpretation. *Science*, *321*, 1831–1834. doi:10.1126/science.1161437.

Zwaan, R. A., Stanfield, R. A., & Yaxley, R. H. (2002). Language comprehenders mentally represent the shapes of objects. *Psychological Science*, *13*, 168–171. doi:10.1111/1467-9280.00430.