JOURNAL OF COGNITION AND DEVELOPMENT, 15(4):527–538

ISSN: 1524-8372 print/1532-7647 online
DOI: 10.1080/15248372.2012.736112

# I See Your Point: Infants Under 12 Months Understand That Pointing Is Communicative

Madelaine Krehm
*New York University*

Kristine H. Onishi
*McGill University, Canada*

Athena Vouloumanos
*New York University*

Do young infants understand that pointing gestures allow the pointer to change the information state of a recipient? We used a third-party experimental scenario to examine whether 9- and 11-month-olds understand that a pointer's pointing gesture can inform a recipient about a target object. When the pointer pointed to a target, infants subsequently looked longer when the recipient selected the nontarget rather than the target object. In contrast, infants looked equally long whether the recipient selected the target or nontarget object when the pointer used a noncommunicative gesture, a fist. Finally, when the recipient had no perceptual access to the pointing gesture, infants looked longer when the recipient selected the target rather than the nontarget object. Young infants understand a fundamental aspect of the communicative function of pointing: Pointing, but not all gestures, can transfer information. Gestures may thus be one of the tools infants use for an early understanding of communication.

Pointing—a gesture in which an extended finger is directed at an object, person, or event—is a critical form of communication for adults. Infants begin to point months before they speak (Bates, 1975; Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Butterworth & Morissette, 1996; Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004). Yet it is an open question whether young infants understand a fundamental *communicative* aspect of pointing gestures: that pointing allows the person pointing to change the information state of a recipient (e.g., Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Liszkowski, Carpenter, & Tomasello, 2007). The alternative view is that early understanding of pointing is noncommunicative, based instead, for example, on learned behavioral contingencies (e.g., pointing as predictive or a means for obtaining something interesting or desirable; Moore & Corkum, 1994; Sodian & Thoermer, 2004), or providing attentional or perceptual spotlighting cues (Moore, 1999). To distinguish between the conflicting proposals of infants' early understanding

Correspondence should be sent to Athena Vouloumanos, Department of Psychology, New York University, 6 Washington Place, New York, NY 10003, USA. E-mail: athena.vouloumanos@nyu.edu

of pointing and to examine the role of pointing in the developing infrastructure of human intentional communication (e.g., Tomasello, 2008; Woodward & Guajardo, 2002), here we use a novel paradigm to directly assess whether infants younger than 1 year old (9- and 11-month-olds) understand that pointing can change a recipient's information state.

By the end of their first year, infants have some understanding of others' information states and recognize that others' information states can differ from the infants' own (Buttelmann, Carpenter, & Tomasello, 2009; Luo, 2011; Luo & Baillargeon, 2007; Luo & Johnson, 2009; Onishi & Baillargeon, 2005; Sodian, Thoermer, & Metz, 2007; Surian, Caldi, & Sperber, 2007). Further, infants are aware of some of the ways in which others' information states can be updated (e.g., with perceptual access to the relevant information; Luo & Baillargeon), and they can take others' perceptions and knowledge into account when interpreting their behavior (Surian et al.). Still, research thus far has been equivocal on whether early infant pointing can update others' information states and thus whether it is used and understood as a communicative act.

One reason that prior studies on pointing cannot disentangle whether infants understand its role in updating information states is that the pointing gesture co-occurred with additional cues (e.g., gaze) and was contrasted with other gestures such as grasping without the additional cues, leaving open the specific role of pointing in these results (e.g., Yoon, Johnson, & Csibra, 2008). A second reason is that the infant has generally been part of the interaction. When the infant is the *recipient* responding to the pointing gesture, one cannot completely rule out responses based on attentional highlighting (perceptual cues provided by the extended finger; Moore, 1999), associations between specific actions or objects and particular people (Liebal, Behne, Carpenter, & Tomasello, 2009; Liszkowski, Carpenter, Striano, & Tomasello, 2006; Liszkowski, Carpenter, & Tomasello, 2008), adaptive automatic responses (as discussed in Behne, Liszkowski, Carpenter, & Tomasello, 2011), or following simple behavioral rules (see also Povinelli & Vonk, 2004), without the understanding that pointing is being used to update an information state. When the infant is the *producer* of the pointing gesture, infants may be pointing to underscore their own attentional focus (Bates, 1975; Butterworth & Morissette, 1996; D'Entremont & Seamans, 2007; Moore & Corkum, 1994; Moore & D'Entremont, 2001), to elicit a behavioral response in others (possibly heightened by their shared or nonshared experiences with others; Franco & Butterworth, 1996; Liebal et al.; Liszkowski, Albrecht, Carpenter, & Tomasello, 2008; Liszkowski et al., 2006, 2007; Liszkowski, Carpenter, et al., 2008; Liszkowski, Schäfer, Carpenter, & Tomasello, 2009; Moore & D'Entremont; O'Neill, 1996; Tomasello & Haberl, 2003), or based on a learned contingency between producing the gesture and receiving attention or a desirable object (Moore & Corkum) without understanding the information-transferring properties of pointing (see also Southgate, van Maanen, & Csibra, 2007). Because pointing has been conflated with the presence of other cues (e.g., eye gaze) and because infants have been participants in the pointing interaction, prior studies have not directly addressed whether infants understand that pointing can change information states.

To avoid these concerns, we used a third-party scenario (e.g., Song, Onishi, Baillargeon, & Fisher, 2008) to separate what the infant knows from what the recipient of the point knows. By independently manipulating what is known by whom, we can verify that infants expect the recipient to act based on the recipient's own knowledge, ruling out the possibility that infants' expectations are based on their own attention or on low-level associations. We build on evidence that infants (1) understand pointing as an object-directed action (Woodward & Guajardo, 2002), (2) expect people to continue to interact with an object with which they had previously interacted (Buresh & Woodward, 2007; Woodward, 1998), and (3) expect people to be cooperative

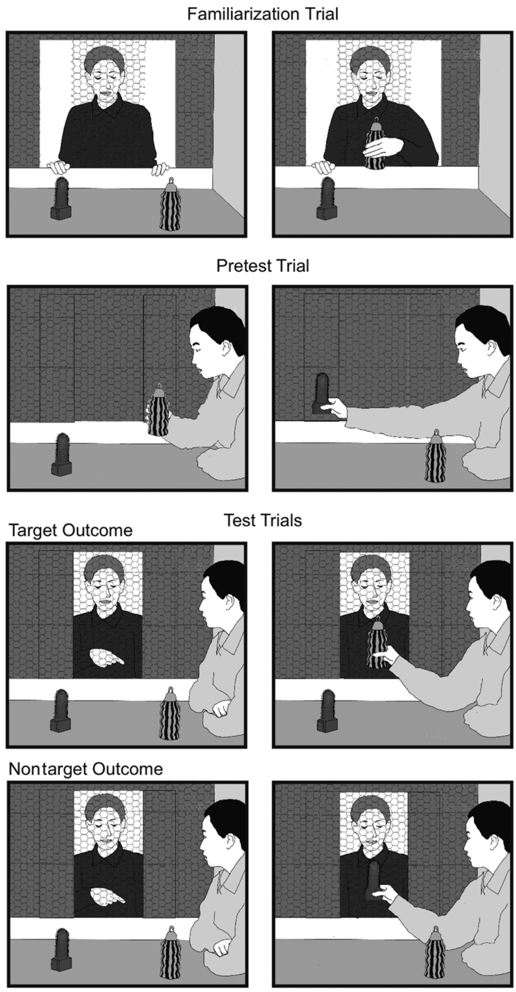


FIGURE 1 Procedure. Familiarization Trials: The pointer looked at two novel objects and then grasped the target object. Pretest Trial: The recipient interacted with both objects. Test Trials: The pointer directed a gesture, in this case a pointing gesture, toward the target object. The recipient then selected the target (Target outcome) or the nontarget (Nontarget outcome) object.

(Warneken & Tomasello, 2007, 2009). We directly assessed whether 9- and 11-month-olds who are in the early phases of pointing production (unlike Song et al., who examined 18-month-olds) understand that pointing can change the information state of a recipient.[1] We focused on infants

[1]In a superficially similar study, 14-month-old infants successfully retrieved a hidden toy after watching a third-party interaction in which a pointer indicated the hidden toy's location for a recipient either intentionally or absent-mindedly (Gräfenhain, Behne, Carpenter, & Tomasello, 2009). In that experiment, however, the dependent variable was infants' response to the pointing gesture, and as such, infants needed only to follow the pointer's intentional point to the correct location themselves; infants did not need to consider the recipient at all.

aged 9 to 11 months old because both pointing behavior (Bates et al., 1979) and understanding of object-directed pointing (Woodward & Guajardo) emerge during this period.

In three experimental conditions, infants saw an actor (the pointer), alone, repeatedly grasp one of two available objects (the target), indicating her preference (e.g., Woodward, 1998). Next, a second actor (the recipient) was introduced, alone, and briefly interacted with both objects, demonstrating no preference. In the test scene, both actors were present; however, due to a scene change, the pointer could no longer grasp the objects whereas the recipient could (see Figure 1). The recipient could intentionally select the pointer's target only if she had the requisite information: specifically, if the pointer produced an informative communicative act (e.g., a pointing gesture), and if the recipient had perceptual access to the communicative act (e.g., could see the gesture).

Our third-party scenario allowed us to determine whether infants understand pointing as communicative. Infants observed an interaction in which there was a potential transfer of information between pointer and recipient and evaluated whether the information state of the recipient was changed. The infants always knew which object was the target (through prior observation of the pointer's selective grasping), but the recipient only *sometimes* had this information. If infants made inferences about the recipient's ability to select the target from their *own* perspective and not from the recipient's, the infants' evaluation of the recipient's ability to select the target would sometimes be incorrect. However, if infants understood that pointing could update information states, they would evaluate the recipient as able to select the target *only* when she had the relevant information through perceptual access to an informative gesture. We predicted that infants would understand that informative gestures such as pointing, but not uninformative gestures (such as a fist), could change the recipient's information state, but only if the recipient had perceptual access to the gesture (if she could see it).

## METHOD

To test whether infants understand that informative gestures such as pointing can change the information state of a recipient, we manipulated the gesture the pointer directed toward a target object. The pointer produced either a potentially informative gesture, pointing with the index finger (Pointing condition), or a potentially uninformative familiar gesture, a closed fist (Fist condition). To test whether infants understand that pointing can update an information state only if the recipient has perceptual access to the gesture, we manipulated the recipient's perceptual access by having her eyes covered during the pointer's pointing gesture (Blindpoint condition). If infants were responding based on the *recipient's* information state, even in the presence of the potentially informative point gesture, they should not evaluate the recipient as able to select the target object.

### Participants

Two groups of full-term infants were tested: 9-month-olds and 11-month-olds. Forty-eight 9-month-old infants (24 females; $M_{\text{age}} = 9.3$ months; range = 8.8–9.8) and fifty-four 11-month-old infants (27 females; $M_{\text{age}} = 11.4$ months; range = 10.8–11.7) participated. Sixteen 9-month-olds and eighteen 11-month-olds were randomly assigned to each of three gesture conditions: Pointing, Fist, or Blindpoint. Data from an additional twenty-three 9-month-olds were excluded due to experimenter error (14), fussiness or inattention (5), environmental interference (3), or a looking time more than three standard deviations greater than the average (1). Data from an additional sixteen 11-month-olds were excluded due to fussiness or inattention (10) and experimenter error (6).

### Stimuli

Two novel cylindrical objects were used: an orange cylinder with a bumpy texture and a cubic base, and a yellow cylinder with blue stripes and a rounded top. The objects were in full view of the infant and both actors, and were within reach of both actors.

### Apparatus

Each infant sat on a caregiver's lap facing a display box. The back wall of the display contained a window covered with wire mesh and a flap permitting the pointer to be visible or not. The right wall from the infant's perspective had a large opening covered by a yellow curtain, permitting the recipient to be visible or not. On each side of the display, panels isolated the participant from the rest of the room. A small peephole in one of the panels allowed an online coder to see the infant while preventing the coder from seeing the events. The online coder recorded the infants' attention to the whole scene by pressing a button on a video game controller attached to a computer running the Windows-based program Baby (Baillargeon & Barrett, 2005). Trial endings were confirmed by an independent coder blind to the condition. A curtain hid the display between trials. Both the infant and the events were recorded on video.

### Design and Procedure

Parents completed a gesture questionnaire adapted from the MacArthur-Bates Communicative Development Inventory: Words and Gestures (MB-CDI; Fenson et al., 1994; Woodward & Guajardo, 2002). Parents were instructed to close their eyes after Familiarization Trial 1. The online coder was blind to the gesture and outcome. As a check for bias, the online coder guessed which object was selected for each test trial. Guesses were at chance as measured by an exact binomial test ($p = .38$).

The experiment was composed of five trials: three familiarization, one pretest, and one test (see Figure 1). Live actors performed a series of choreographed movements in time to a metronome clicking once per second. Each trial consisted of an initial section, when the actors performed the informative actions, and a main section, when the actors remained still or performed a repetitive, noninformative action. Infants controlled the length of the main section of the trial: The trial ended when the infant looked away for 2 consecutive seconds after having looked for at least 2 seconds during the main section of the trial, or after the infant looked for the trial maximum. The infants' looking times during the main section are reported. The ending of each trial was signaled by a beep, cuing the actors to freeze in position and the curtain to be lowered.

*Familiarization.* When the curtain rose, the pointer was visible through the mesh-covered window and had access to the objects through the open doors (see Figure 1, Familiarization Trial). She wore a black shirt to maximize the visibility of her gesture against her torso. After looking at the two objects, the pointer grasped one (the target) to establish her preference for it (Woodward, 1998). Specifically, the pointer looked at one object (2 seconds), the other object (2 seconds), looked at the object that would be the target (1 second), grasped it (1 second), raised it (1 second), brought it toward herself (1 second), and tilted its top toward the infant (1 second), then toward herself (1 second). This 10-second sequence comprised the initial section. During the infant-controlled main section, the pointer continued tilting the object until the trial ended (maximum 18 seconds). The familiarization trial was presented three times. The target object (orange, yellow) and its location (left, right) remained constant within each infant. In each gesture condition, 17 infants saw the orange object as target, and 17 saw the yellow object as the target. In the Point and Fist conditions, 17 saw the target on the left, 17 saw it on the right; for Blindpoint, 18 infants saw the target on the left and 16 infant saw it on the right.

*Pretest.* When the curtain rose, the recipient was visible on the right side of the display. The pointer was no longer visible (see Figure 1, Pretest Trial). The recipient handled each object for an equal amount of time, indicating that she could reach both objects and had no preference (Buresh & Woodward, 2007). Specifically, the recipient looked at one object (2 seconds) and then the other object (2 seconds). Next, she looked back at the first object (1 second), grasped it (1 second), raised it (1 second), tilted it toward and away from herself (2 seconds), set it down (1 second), and retracted her hand (1 second). She then performed the same look–tilt–retract action sequence (7 seconds) on the second object. During the main trial section, the recipient repeated her look–tilt–retract actions on each of the objects until the trial ended (maximum 15 seconds).

*Test.* Both actors were present together for the first time in their respective locations, but the pointer's doors were closed, such that she could see but not reach the objects (see Figure 1, Test Trials). At this point, the pointer pointed toward the target object while the recipient watched (Point condition, Figure 2), directed her fist toward the target object while the recipient watched (Fist condition, Figure 2), or pointed toward the target object while the recipient covered her eyes and faced away from the pointer until the pointer finished producing the gesture (Blindpoint condition, Figure 2). The recipient then either selected the target or the nontarget.

Specifically, after the curtain rose, infants accumulated 2 seconds of looking time to ensure that their attention was directed at the scene. Then, while the recipient watched, the pointer

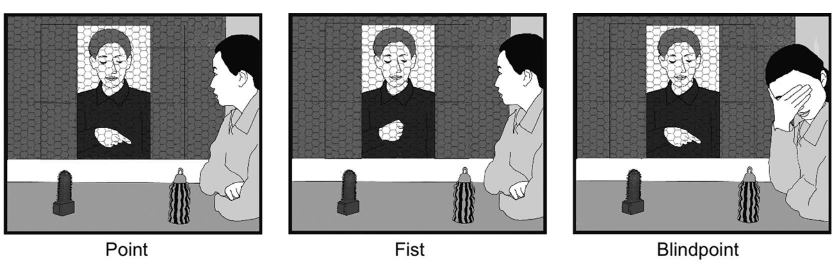


FIGURE 2 The critical gesture in each gesture condition.

looked at one object (2 seconds), at the other object (2 seconds), at the recipient (2 seconds), then down at her own hand (1 second), and gestured at the target using the hand contralateral to the object positioned at the midline of her torso (1 second). Next, the pointer looked at the recipient (1 second), looked down at her own hand (1 second), repeated the gesture by raising and lowering her forearm from her elbow (1 second) while maintaining her hand shape, looked at the recipient (1 second), and lowered her hand from view while maintaining eye contact with the recipient (2 seconds). At no time did the pointer look at the target, so infants could not use her gaze as a cue. The recipient, who had been looking at the gesture (Point and Fist conditions) or who had covered her eyes with her hand during the gesture (Blindpoint condition), looked at the pointer's face (1 second), looked at one of the objects (1 second), grasped it (1 second), raised it (1 second), and brought it near the pointer, holding it just below her face (1 second). The pointer's gaze followed the recipient's movements. For half the infants in each gesture condition and age, the recipient selected the target object (Target outcome), and for half, the recipient chose the nontarget object (Nontarget outcome). The main trial section began after the recipient froze holding the selected object; actors remained still until the trial ended (maximum 40 seconds).

## RESULTS

The mean looking times and standard errors for the main sections of the test trials for each gesture condition and outcome are shown in Figure 3. Infants looked longer at the Nontarget outcome only when the pointer used a pointing gesture and the recipient had perceptual access to that gesture. An age (9 months, 11 months) × gesture (Point, Fist, Blindpoint) × outcome (Target, Nontarget) univariate analysis of variance (ANOVA) showed a reliable interaction between gesture and outcome, $F(1, 90) = 7.76$, $p = .001$, $\eta_p^2 = .12$. In addition, there was a main effect of condition, $F(1, 90) = 8.16$, $p = .001$, $\eta_p^2 = .07$, driven by overall longer looking times in the

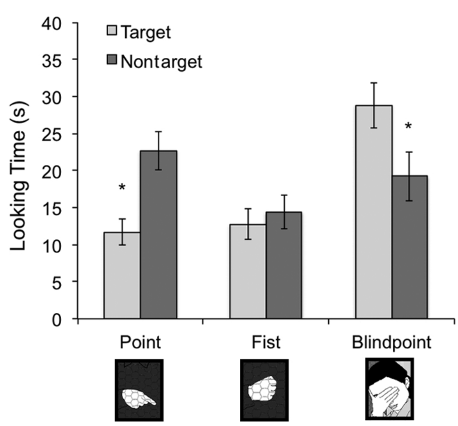


FIGURE 3 Results. Mean looking time for test trials across infants (in seconds) and standard error of the mean for each outcome (Target, Nontarget) for each gesture condition. An asterisk (*) represents significance at $p < .05$ between the outcomes within a gesture condition. Interactions are reported in the main text.

Blindpoint condition and a marginal effect of age, $F(1, 90) = 3.20$, $p = .077$, $\eta_p^2 = .04$, due to longer overall looking by 11-month-olds ($M = 20.1$ seconds, $SE = 1.5$) compared with 9 month-olds ($M = 16.2$ seconds, $SE = 1.6$). As age did not interact with any other variable, $F\text{s} < 1$, $p = ns$, we collapsed over age for the remaining analyses.

Within each gesture condition, longer looking times to the Nontarget than the Target outcome would suggest that infants understood that the gesture had allowed the pointer to transfer information to the recipient about which object was her target. In the Point condition, infants looked longer at the Nontarget than at the Target outcome, $t(32) = 3.46$, $p = .002$, *Cohen's* $d = 1.60$. However, in the Fist condition, looking times were equal for Nontarget and Target outcomes, $t(32) = 0.53$, $p = .600$, $d = 0.18$. The interaction between Fist and Point was reliable, $F(1, 60) = 4.44$, $p = .039$, $\eta_p^2 = .06$, consistent with infants understanding that the recipient would respond differently to the pointer's pointing and fist gestures. Nonparametric Wilcoxon Signed-Rank Tests confirmed the differences within each gesture condition (Point, $Z = 3.14$, $p = .002$; Fist, $Z = 0.655$, $p = .510$). In the Blindpoint condition, infants looked longer at the Target than the Nontarget outcome, $t(32) = 2.13$, $p = .041$, $d = 0.73$; Wilcoxon $Z = 2.12$, $p = .034$, consistent with the possibility that infants found it surprising when the recipient selected the target because she had no way of knowing which object was the target. Critically, the interaction between Point and Blindpoint was reliable, $F(1, 60) = 13.67$, $p < .001$, $\eta_p^2 = .164$, consistent with infants' understanding that for successful information transfer, the recipient must be able to perceive the signal.

We next examined whether infants' understanding of pointing was influenced by infants' own skill at object-directed pointing, as comprehension has been related to motor performance in other cognitive tasks (e.g., Sommerville, Woodward, & Needham, 2005; Woodward & Guajardo, 2002). Infants were considered to be pointers if they produced a minimum of one object-directed pointing gesture during their lab visit or if parents indicated that the infant pointed to objects at home (following the criteria of Woodward & Guajardo, 2002, using the adapted MB-CDI questionnaire). Of the 96 infants for whom we had parental reports, 53 infants were classified as pointers and 43 were nonpointers. Pointers and nonpointers were roughly equally distributed across the six gesture (3) × outcome (2) cells, although because infants were randomly assigned to conditions/outcomes prior to their visit, cells contained unequal numbers of pointers and nonpointers. A pointing skill (pointer, nonpointer) × gesture (Point, Fist, Blindpoint) × outcome (Target, Nontarget) ANOVA showed no main effect of pointing skill ($F < 1$, $p = ns$) and no interactions of pointing skill with other variables (all $F\text{s} < 1$); thus, although skill at pointing seems to be related to understanding pointing as object-directed (e.g., Woodward & Guajardo), a recipient found no influence of pointing skill on infants' understanding that pointing can update information states.

We performed three sets of analyses to verify that other factors did not account for our effects of interest. First, to verify that there were no differences in infant attentiveness before the test trial, we conducted the age (9 months, 11 months) × gesture (Point, Fist, Blindpoint) × outcome (Target, Nontarget) ANOVA on the sum of the looking times to the four trials before the test trial. We found no differences in looking time (all $F\text{s} < 1.80$), except for a main effect of age, $F(1, 90) = 14.28$, $p < .001$, $\eta_p^2 = .13$, with 11-month-olds again looking longer than 9-month-olds.

Second, we examined effects of both target object and location with age (9 months, 11 months) × gesture (Point, Fist, Blindpoint) × outcome (Target, Nontarget) ANOVAs. Although there was no effect of target location ($F$s < 1.50), there was a main effect of target object, $F(1, 90) = 4.67$, $p = .033$, $\eta_p^2 = .03$, qualified by a target object × gesture interaction, $F(2, 90) = 3.64$, $p = .030$, $\eta_p^2 = .05$. Infants in the Blindpoint condition looked longer during test when the Target was the yellow object ($M = 30.4$ seconds, $SE = 2.6$) than they did when it was the orange object ($M = 18.3$ seconds, $SE = 2.4$), while in the Point ($M = 17.2$ seconds, $SE = 2.4$ vs. $M = 17.2$ seconds, $SE = 2.6$) and Fist ($M = 14.1$ seconds, $SE = 2.4$ vs. $M = 13.1$ seconds, $SE = 2.6$) conditions, infants looked equally regardless of which object was the target. Because there was no interaction with outcome, this bias to look longer when the yellow object was the target in the Blindpoint condition cannot explain our main findings—that infants assess the Target and Nontarget outcomes differently depending on the gesture condition.

Third, we examined whether the gestures differentially highlighted the target object (e.g., Moore, 1999), thus drawing infants' attention to the target object to different degrees across the gesture conditions. For the 102 infants, a coder blind to the outcome and gesture coded infant looking to the target object region frame-by-frame during the 5-second gesturing portion of each test trial (starting with the frame in which the pointer produced the first gesture and ending with the frame just prior to the recipient initiating a movement). For each frame (30 frames/second), when the target was on the left (right), coders judged whether infants fixated on the lower left (right) of the display box or not. A second blind coder coded 60% of the trials. For 10 trials across the three conditions that had differences larger than 50 milliseconds, discrepancy was resolved by discussion. Across the two coders, total looking times across trials to the target object region during the gesture period were highly correlated ($r = .94$). Infants looked equally long at the target object region during the Point and Fist gestures (540 ms vs. 505 ms), $t(66) = 0.12$, $p = ns$, and during the Point and Blindpoint (540 ms vs. 711 ms), $t(66) = 0.98$, $p = ns$. The reliable looking-time difference between the Point, Fist, and Blindpoint test trials cannot be explained by differences in attention to the target object.

## DISCUSSION

Using a third-party experimental scenario, we examined whether 9- and 11-month-old infants, who are in the early phases of pointing production, understand that pointing can update the information state of a recipient about a pointer's target object. When the pointer directed her index finger toward the target and the recipient had perceptual access to the gesture, infants looked longer when the recipient selected the nontarget. In contrast, when the pointer directed a fist toward the target, or when the recipient could not see the pointer's pointing gesture, infants did not do so. In our scenario, infants construed gesturing with an extended index finger—but not a fist—as informative for a recipient, but only when the recipient had perceptual access to the gesture. Infants as young as 9 months thus understand one important aspect of the communicative function of pointing: that it can update the recipient's information state.

The ability to evaluate actions based on the actors' perceptual experience—especially when it differs from the infants' own experience—requires infants to track the other person's perception of the scene separately from their own (Luo, 2011; Luo & Baillargeon, 2007; Luo & Johnson, 2009). Infants in the current experiment had direct knowledge of the pointer's target because they witnessed her selective grasping of it. Despite this knowledge, infants only evaluated the recipient as able to select the target when she had perceptual access to a potentially informative gesture. Infants were reasoning from the perspective of the recipient and not from their own perspective, adding to the evidence from prior studies that they track separate representations of the scene.

Infants responded differently to the two situations in which the pointer did not transfer information (the Fist and Blindpoint conditions). When the pointer used a fist, infants looked equally long whether the recipient selected the target or nontarget object. In contrast, when the pointer produced a pointing gesture that the recipient could not see, infants looked longer when the recipient subsequently selected the target object, compared with the nontarget object. This pattern of longer looking times for the target compared with the nontarget outcome is consistent with previous findings—using a similarly structured third-party scenario—in which infants evaluated the potential of different vocalizations for information transfer (Martin, Onishi, & Vouloumanos, 2012). There, infants showed the same reversal of looking time when the actor communicated using a vocalization that was communicative but insufficient to allow the recipient to select the target object in the scenario (e.g., a positive emotional vocalization). They showed no such reversal when the vocalization was not communicative (e.g., a cough). Infants in the current experiment may have similarly evaluated the pointer's pointing gesture as a communicative attempt that failed when the recipient could not perceive it. When infants detect a communicative attempt, they might actively evaluate whether that attempt allows a recipient to select the target.

We found no evidence that infants' own pointing behavior was related to their understanding of pointing in a third-party scenario. This seems to contrast with previous work demonstrating that infants' interpretation of simple grasping or object-directed pointing was mediated by the infants' own ability to perform the action. Only infants who were pointing in an object-directed manner interpreted an experimenter's pointing as indicating which of two objects she would be likely to interact with (Woodward & Guajardo, 2002; see also Sommerville et al., 2005). One key difference is in our use of a third-party interaction: Observing a communicative interaction between people about an object might be different from watching a person interact with an object. Such differences between third- and first-party interactions are also evident in how infants interpret the referential scope of vocalizations (Csibra & Gergely, 2009; Vouloumanos, Onishi, & Pogue, 2012).

The current results provide evidence for a basic understanding of the communicative function of pointing at an age at which infants themselves are just starting to produce pointing in triadic interactions. Previous studies have shown that infants understand that pointing is object-directed (Woodward & Guajardo, 2002) and can influence the behavior of others (D'Entremont & Seamans, 2007; Liszkowski et al., 2006). Our results suggest, in addition, that infants younger than 1 year of age understand that pointing can update the information state of a recipient. This raises the compelling possibility that infants' own first pointing gestures, produced between 9 and 12 months, may already be grounded in an understanding of the communicative function of the gesture. Previous work had left open other possibilities—for example, that infants point to initiate a state of joint attention with an adult rather than to attempt to change the adult's information state (Liszkowski, Carpenter, et al., 2008; Liszkowski et al., 2006)—but the current experiment supports a communicative interpretation of the earlier studies. In contrast to a developmental pattern in which infants begin to point regardless of the potential recipient's attentional focus (D'Entremont & Seamans), infants may use pointing to attempt to transfer information and thus understand pointing as communicative from its earliest use.

## REFERENCES

Baillargeon, R., & Barrett, J. (2005). *Baby. An experimental software program for infant looking time experiments* [Computer software]. http://internal.psychology.illinois.edu/labs/ICL_downloads/babyprogram/babyprogram.php>.

Bates, E. (1975). The acquisition of performatives prior to speech. *Merrill-Palmer Quarterly*, *21*, 205–226.

Bates, E., Benigni, L., Bretherton, I., Camaioni, L., & Volterra, V. (1979). *The emergence of symbols: Cognition and communication in infancy*. New York, NY: Academic Press.

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:10.1111/j.2044-835X.2011.02043.x.

Buresh, J. S., & Woodward, A. L. (2007). Infants track action goals within and across agents. *Cognition*, *104*, 287–314. doi:10.1016/j.cognition.2006.07.001

Buttelmann, D., Carpenter, M., & Tomasello, M. (2009). Eighteen-month-old infants show false belief understanding in an active helping paradigm. *Cognition*, *112*, 337–342. doi:10.1016/j.cognition.2009.05.006

Butterworth, G., & Morissette, P. (1996). Onset of pointing and the acquisition of language in infancy. *Journal of Reproductive and Infant Psychology*, *14*, 219–231. doi:10.1080/02646839608404519

Camaioni, L., Perucchini, P., Bellagamba, F., & Colonnesi, C. (2004). The role of declarative pointing in developing a theory of mind. *Infancy*, *5*, 291–308. doi:10.1207/s15327078in0503_3

Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, *63*, l–174.

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences*, *13*, 148–153. doi:10.1016/j.tics. 2009.01.005

D'Entremont, B., & Seamans, E. (2007). Do infants need social cognition to act socially? An alternative look at infant pointing. *Child Development*, *78*, 723–728. doi:10.1111/j.1467-8624.2007.01026.x

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., & Pethick, S. J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*, 1–173.

Franco, F., & Butterworth, G. (1996). Pointing and social awareness: Declaring and requesting in the second year. *Journal of Child Language*, *23*, 307–336.

Gräfenhain, M., Behne, T., Carpenter, M., & Tomasello, M. (2009). One-year-olds' understanding of nonverbal gestures directed to a third person. *Cognitive Development*, *24*, 23–33. doi:10.1016/j.cogdev.2008.10.001

Liebal, K., Behne, T., Carpenter, M., & Tomasello, M. (2009). Infants use shared experience to interpret pointing gestures. *Developmental Science*, *12*, 264–271. doi:10.1111/j.1467-7687.2008.00758.x

Liszkowski, U., Albrecht, K., Carpenter, M., & Tomasello, M. (2008). Infants' visual and auditory communication when a partner is or is not visually attending. *Infant Behavior & Development*, *31*, 157–167. doi:10.1016/j.infbeh. 2007.10.011

Liszkowski, U., Carpenter, M., Striano, T., & Tomasello, M. (2006). 12- and 18-month-olds point to provide information for others. *Journal of Cognition & Development*, *7*, 173–187. doi:10.1207/s15327647jcd0702_2

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:10.1111/j.1467-7687.2006.00552.x

Liszkowski, U., Carpenter, M., & Tomasello, M. (2008). Twelve-month-olds communicate helpfully and appropriately for knowledgeable and ignorant partners. *Cognition*, *108*, 732–739.

Liszkowski, U., Schäfer, M., Carpenter, M., & Tomasello, M. (2009). Prelinguistic infants, but not chimpanzees, communicate about absent entities. *Psychological Science*, *20*, 654–660. doi:10.1111/j.1467-9280.2009.02346.x

Luo, Y. (2011). Do 10-month-old infants understand others' false beliefs? *Cognition*, *121*, 289–298.

Luo, Y., & Baillargeon, R. (2007). Do 12.5-month-old infants consider what objects others can see when interpreting their actions? *Cognition*, *105*, 489–512. doi:10.1016/j.cognition.2006.10.007

Luo, Y., & Johnson, S. C. (2009). Recognizing the role of perception in action at 6 months. *Developmental Science*, *12*, 142–149. doi:10.1111/j.1467-7687.2008.00741.x

Martin, A., Onishi, K. H., and Vouloumanos, A. (2012). Understanding the abstract role of specch in communication at 12 months. *Cognition*, *123*, 50–60.

Moore, C. (1999). Intentional relations and triadic interactions. In P. D. Zelazo, J. W. Astington, & D. R. Olson (Eds.), *Developing theories of intention: Social understanding and self-control* (pp. 43–61). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Moore, C., & Corkum, V. (1994). Social understanding at the end of the first year of life. *Developmental Review*, *14*, 349–372.

Moore, C., & D'Entremont, B. (2001). Developmental changes in pointing as a function of attentional focus. *Journal of Cognition & Development*, *2*, 109–129. doi:10.1207/S15327647JCD0202_1

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.

Onishi, K. H., & Baillargeon, R. (2005). Do 15-month-old infants understand false beliefs? *Science*, *308*, 255–258. doi:10.1126/science.1107621

Povinelli, D. J., & Vonk, J. (2004). We don't need a microscope to explore the chimpanzee's mind. *Mind & Language*, *19*, 1–28.

Sodian, B., & Thoermer, C. (2004). Infants' understanding of looking, pointing, and reaching as cues to goal-directed action. *Journal of Cognition & Development*, *5*, 289–316. doi:10.1207/s15327647jcd0503_1

Sodian, B., Thoermer, C., & Metz, U. (2007). Now I see it but you don't: 14-month-olds can represent another person's visual perspective. *Developmental Science*, *10*, 199–204. doi:10.1111/j.1467-7687.2007.00580.x

Sommerville, J. A., Woodward, A. L., & Needham, A. (2005). Action experience alters 3-month-old infants' perception of others' actions. *Cognition*, *96*, B1–11.

Song, H., Onishi, K. H., Baillargeon, R., & Fisher, C. (2008). Can an agent's false belief be corrected by an appropriate communication? Psychological reasoning in 18-month-old infants. *Cognition*, *109*, 295–315. doi:10.1016/j.cognition.2008.08.008

Southgate, V., van Maanen, C., & Csibra, G. (2007). Infant pointing: Communication to cooperate or communication to learn? *Child Development*, *78*, 735–740. doi:10.1111/j.1467-8624.2007.01028.x

Surian, L., Caldi, S., & Sperber, D. (2007). Attribution of beliefs by 13-month-old infants. *Psychological Science*, *18*, 580–586. doi:10.1111/j.1467-9280.2007.01943.x

Tomasello, M. (2008). *Origins of human communication*. Cambridge, MA: MIT Press.

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

Vouloumanos, A., Onishi, K. H., & Pogue, A. (2012). Twelve-month-old infants recognize that speech can communicate unobservable intentions. *Proceedings of the National Academy of Sciences of the United States of America*, *109*, 12933–12937. doi:10.1073/pnas.1121057109

Warneken, F., & Tomasello, M. (2007). Helping and cooperation at 14 months of age. *Infancy*, *11*, 271–294.

Warneken, F., & Tomasello, M. (2009). Varieties of altruism in children and chimpanzees. *Trends in Cognitive Sciences*, *13*, 397–402.

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, *69*, 1–34. doi:S0010-0277(98)00058-4

Woodward, A. L., & Guajardo, J. J. (2002). Infants' understanding of the point gesture as an object-directed action. *Cognitive Development*, *17*, 1061–1084.

Yoon, M. D., Johnson, M. H., & Csibra, G. (2008). Communication-induced memory biases in preverbal infants. *Proceedings of the National Academy of Sciences of the United States of America*, *105*, 13690–13695.