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# The Effect of a Looker's Past Reliability on Infants' Reasoning About Beliefs

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We investigated whether 16-month-old infants' past experience with a person's gaze reliability influences their expectation about the person's ability to form beliefs. Infants were first administered a search task in which they observed an experimenter show excitement while looking inside a box that either contained a toy (reliable looker condition) or was empty (unreliable looker condition). The infants were then administered a true belief task in which they watched as the same experimenter hid a toy in 1 of 2 locations. In the test trial, the infants witnessed the experimenter search for the toy in a location that was consistent or inconsistent with her belief about the toy's location. Results for the true belief task indicated that only the infants in the reliable looker condition looked longer at the incongruent than at the congruent search behavior. These findings are consistent with evidence suggesting that infants encode the identity of agents based on past reliability and implicitly attribute beliefs to others during the 2nd year of life.

*Keywords:* infancy, social cognition, theory of mind, belief, credibility

For the past two decades, a common way in which researchers have examined children's developing theory of mind (ToM) has been by examining their understanding of false beliefs. A well-established consensus posits that children younger than 4 years of age lack a ToM because they have been shown to repeatedly fail the standard false belief task (Wellman, Cross, & Watson, 2001; Wimmer & Perner, 1983), whereas passing suggests that infants have a conceptual understanding of another person's mental state (Gomez, 2004). On the basis of this view, infants before the age of 4 years lack a representation of the mind and are incapable of understanding other people's actions as a function of their mental state. However, others have argued that succeeding on a false belief task not only entails understanding other people's mental states but also requires abilities, such as inhibitory control (Carlson, Molson, & Hix, 1998; Gerstadt, Hong, & Diamond, 1994; Hood, 1995; Zelazo, Frye, & Rapus, 1996), linguistic competence (Miller, 2001), and the ability to select the correct response (Leslie, German, & Polizzi, 2005). In particular, the standard false belief task with a hidden toy requires that the child be capable of responding correctly while putting aside his or her knowledge about the hidden toy's actual location and be able to correctly interpret the "where" question as referring to the agent's subsequent actions (Csibra & Southgate, 2006) and not the location of the hidden object (Southgate, Senju, & Csibra, 2007).

Recent research on early-developing ToM mechanisms has revealed that infants in the middle of their 2nd year of life show an implicit understanding of other people's true and false beliefs. In a recent series of studies, Poulin-Dubois and colleagues (Poulin-Dubois, Sodian, Metz, Tilden, & Schoeppner, 2007) examined an implicit form of seeing = knowing by testing infants' expectation about a person's search for a hidden object as a function of that person's prior visual experience or lack thereof. Using the violation of expectancy paradigm and a forced-choice procedure based on the preferential looking paradigm, Poulin-Dubois et al. exposed infants to videotaped events in which a person either did or did not witness where an object was located. This was followed by the presentation of two still frames that depicted the person pointing at the correct and incorrect location for the object. Thus, one still frame reflected the actor's knowledge of the location of the object, whereas the other still frame reflected her ignorance. The authors expected that if the infants understood that the actor had a visual experience that directly influenced her behavior, the infants would look longer at the unexpected events: the person pointing at the incorrect location for the object when she had seen where it was located and the person pointing at the correct location for the object when she was unable to see where it was located. Poulin-Dubois et al.'s results showed a developmental progression in infants' understanding of seeing: When eye gaze was paired with body orientation, the pattern of results suggested that 18-month-olds expected that someone who saw the location of a hidden object would search for that object successfully, whereas someone who did not see the location of that object would search unsuccessfully. Thus, the 18-month-olds' behavior suggests that they understand what others can and cannot see at a particular moment and, moreover, know that what others have seen influences their

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subsequent behavior. By 24 months of age, the infants inferred a person's search behavior as a function of that person's visual experience when eye gaze was the sole cue. In contrast to the older age groups, 14-month-olds did not discriminate between the person's search behaviors as a function of the person's prior visual experience.

A number of studies have shown that infants in their 2nd year of life can attribute false beliefs to agents (Onishi & Baillargeon, 2005; Song, Onishi, Baillargeon, & Fisher, 2008). For example, Onishi and Baillargeon (2005) showed that 15-month-olds expected an agent's search behavior to be guided by her true or false belief about a hidden toy's location. Specifically, using a violation of expectation paradigm, Onishi and Baillargeon familiarized 15-month-old infants to an event that involved an agent hiding a toy in Box A. Next, the infants observed as the agent witnessed (true belief condition) or did not witness (false belief condition) a change in the toy's location from Box A to Box B. During the test trial, the infants watched as the agent reached for the object in the correct location (Box B) or in the incorrect location (Box A). It is interesting that the infants in the true belief condition looked reliably longer and therefore seemed surprised when the agent searched in the incorrect location, whereas the opposite pattern was observed for the false belief condition. This suggests that the infants expected the agent to search in the location where she believed the toy to be hidden regardless of the toy's true location.

Further evidence supporting an early form of false belief understanding recently came from Southgate et al. (2007), who used a predictive looking paradigm to measure infants' expectation of where the agent will search for a hidden target object. Specifically, they tested 25-month-olds with a nonverbal false belief task that involved recording the infants' anticipatory looking behavior while they watched actions on a computer monitor. Consistent with Onishi and Baillargeon's (2005) findings, the infants gazed in anticipation toward a location where the agent was expected to search if he or she held a false belief, suggesting that infants can suspend their belief about the hidden toy's true location and correctly predict the behavior of the agent in terms of his or her false belief. Other evidence that demonstrates that infants younger than 3 years of age do not wholly lack the ability to attribute beliefs to others came from a study conducted by Surian, Caldi, and Sperber (2007). Using computer animations and measuring their looking time, Surian et al. tested whether 13-month-olds expected agents to behave in a way that was consistent with the information to which they had been exposed. Results revealed that the infants interpreted an agent's future actions toward an object by taking into account the agent's previous exposure to relevant information about the object's location. Taken together, these studies provide compelling evidence of some form of understanding of beliefs much earlier than has been revealed by standard tasks used to test older children's reasoning about other people's mental states.

In contrast to this "rich" mentalistic interpretation of findings, proponents of a "lean" interpretation have argued that infants' performance on the nonverbal false belief tasks need not require an understanding of the connection between the person's mind and his or her actions. Instead, they propose at least two alternative explanations to account for this apparently precocious competence (Perner & Ruffman, 2005; Sirois & Jackson, 2007). One possible explanation is based on infants' ability to form three-way agent–object–place associations. According to this explanation, infants' looking time at an event will be longer when they are processing a new association because they are examining a new combination of the elements compared with a previous association, in which the combination of elements is familiar. Another possible explanation for infants' performance on the nonverbal false belief tasks is based on behavioral rules. Specifically, infants have learned or are innately predisposed to assume that people look for objects where they last saw them and not because that is where the object actually is. As such, infants may follow the rule without any awareness of the mind acting as a mediator. Therefore, any conclusions drawn about infants' implicit understanding of other people's beliefs and their actions will have to rule out these two rival lean hypotheses.

One possible way to address this debate is by examining the effect of an agent's reliability on infants' attribution of beliefs. Previous research with preschoolers has shown that they can appraise the reliability of their informants (Harris, 2007). For example, when presented with two informants, one who provides consistently accurate names for familiar objects and one who provides consistently inaccurate names, 4-year-olds prefer the names offered by the reliable informant to label new objects (Clément, Koenig, & Harris, 2004; Koenig, Clément, & Harris, 2004). Other research has shown that 3-year-olds learn new words from confident rather than uncertain speakers (Sabbagh & Baldwin, 2001).

Recently, this line of research was extended to the infancy period. Specifically, Chow, Poulin-Dubois, and Lewis (2008) examined whether the reliability of a person's past looking behavior will influence 14-month-olds' decision to follow the person's gaze to a target in front and behind a barrier. First, the infants completed a training task in which they watched the experimenter show excitement while looking into a container that had a toy (reliable looker condition) or was empty (unreliable looker condition). Subsequently, they observed the same actor looking at a target object that was visible to the child in front of a barrier (control condition) and at a target object behind a barrier (experimental condition) that was concealed from the child but visible to the actor. For each condition, the infants' gaze following was measured by examining whether the infants moved a short distance to look or point at the looker's target. Results revealed that infants in the reliable looker condition were more likely to follow the gaze of the actor to the target behind the barrier compared with infants in the unreliable looker condition. In contrast, when the target was visible to the infants, those in both looker groups followed the gaze of the looker to the target equally often.

To confirm that the infants in the unreliable looker group were avoiding the agent due to selective mistrust, Chow et al. (2008) used a switch-actor design in a follow-up study. In fact, when the infants were trained with an unreliable looker in the search task and then tested with an unfamiliar looker in the barrier task, the infants treated the new looker as though she was reliable by following her gaze to the front and behind the barrier equally often as the infants in the reliable looker condition in the first experiment. In contrast, the infants followed the unfamiliar looker's gaze behind the barrier more often than those in the unreliable looker condition in the first study, whereas no differences in their gaze following were found to the target in front of the barrier between the two looker groups. Taken together, these findings provide the

first evidence that infants can track the reliability of the looker's gaze across contexts and have an understanding of the subjective nature of gaze. Therefore, it would be interesting to explore whether the reliability of the looker will have an effect on infants' attribution of beliefs based on visual experience (seeing = knowing).

In the present study we examined whether 16-month-old infants' attribution of beliefs to an agent in a nonverbal false belief task is influenced by the agent's prior record of reliability in a gaze-following task. To test this idea, we first trained the infants to develop trust or mistrust of a person. Following the Chow et al. (2008) procedure, we designed the study so that the infants either found (reliable looker condition) or did not find (unreliable looker condition) a toy inside a container after witnessing an experimenter show excitement while gazing at its contents. After the reliability training, the infants completed the true belief task developed by Onishi and Baillargeon (2005). If infants differentially attribute beliefs to an agent on the basis of her past looking behavior (rich interpretation), then those in the unreliable looker condition should have more difficulty attributing beliefs to that experimenter. The reason for this may lie with the infants' prior exposure to misleading attentional cues by that experimenter who looked excitedly into an empty box. Consequently, the infants would experience difficulties in making a connection between the looker's visual attention, while the toy was being hidden, and her subsequent search behavior. In contrast, infants who were exposed to a person's reliable attentional cues would be able to correctly predict that person's search behavior on the basis of her visual experience. As a result, we expected that only the infants in the reliable looker condition would look longer at the test event when the actor searched for the hidden toy in the wrong location than when the actor searched in the correct location. However, if infants have simply developed (or possess innately) the behavioral rule that people tend to look for objects where they last saw them or are simply processing a new combination of events (lean interpretation), then the infants in both looker groups would look longer at the test event when the actor searched for the target object in the wrong location.

## Method

### *Participants*

Forty-nine 16-month-old infants participated in the study. Twenty-two infants were assigned to the reliable looker group (10 boys and 12 girls; *M* age = 16.27 months, range = 15.03 to 17.46 months), and 27 infants were assigned to the unreliable looker group (20 boys, 7 girls; *M* age = 16.45 months, range = 15.49 to 19.13 months). The ages of the infants assigned to the reliable and unreliable looker groups did not significantly differ, $t(47) = 1.26$, $p = .22$. Thirty-four additional infants were excluded from the study because of fussiness ($n = 6$), shyness ($n = 2$), parental interference ($n = 1$), experimenter error ($n = 5$), technical error ($n = 7$), failure to examine contents of container on more than half the training trials on the search task ($n = 3$), and looking at the experimenter but not looking at either box locations during the test trial of the true belief task ($n = 10$). On the basis of parental report, all infants had a minimum of a 35-week gestation period and had no vision or hearing impairments. Most participants were Caucasian and came from middle-class backgrounds, although race and socioeconomic status data were not collected. All infants were recruited via birth records provided by a government health services agency.

### *Materials*

*Search task.* The materials that were used included a child seat attached to a table and three opaque cylindrical plastic containers with loose-fitting lids to administer the training task. These containers differed in color (one yellow, one blue, one orange) but were identical in their dimensions (10 cm diameter, 11 cm height). The number of times each colored container was used was counterbalanced across the four training trials. Two blocks (one blue, one pink) were used in the warm-up trials, and four small toys (teddy bear, fish, ladybug, cat) that produced a sound effect when manipulated were used in the training trials in the reliable looker condition. Two video cameras were used to record the testing session: One was focused on the infant, and the other was focused on the experimenter.

*True belief task.* The materials that were used included a child seat that was attached to a table facing a puppet theater, which was approximately 90 cm away. A red cup covered by colorful stickers rested on the stage 18 cm between two boxes, one yellow and one green (14 cm width, 14 cm length, 14 cm height). Each box had an opening that was covered with a fabric fringe that matched the color of the box. A rectangular opening (8.9 cm width, 10.8 cm height) was cut underneath the box to facilitate the attraction between the magnet located inside the cup (2.5 cm width, 5.0 cm length, 0.6 cm height) and the magnet (7.6 cm diameter) operated by the experimenter, from underneath the stage, to move the cup to a target location. Above the experimenter's head, a camera lens protruded from an opening on the back panel of the puppet theater and was focused on the infant's face. The recordings were later used to code the direction of the infants' gaze during each trial. In addition, the infants' looking time for each trial was monitored and coded live by a second experimenter using the Habit program (version 7.8, University of Texas) on a Mac G4 computer. The experimenter and computerized equipment were concealed from the infant behind a divider. Before and between trials, the contents of the stage were concealed by blinds, which were operated by the experimenter.

### *Design and Procedure*

The infants were first brought to a reception room where they were familiarized with the experimenter while their parents completed the consent forms and were given instructions about the procedure. Following this warm-up period, the infant and parent were brought into the testing room, where the infants first completed the search task, followed by the true belief task. The infants were randomly assigned to one of two conditions: a reliable looker condition and an unreliable looker condition. All the observations were videotaped.

*Search task.* A modified version of Repacholi's (1998) procedure was used (see Chow et al., 2008). This task was designed to make infants develop knowledge about the credibility of a looker. In the reliable looker condition, the infants found a toy in a container after observing the experimenter look inside it while showing positive affect. In the unreliable looker condition, the

infants observed the same demonstration but found the container empty. The infants in each group completed two warm-up trials and four training trials. Responses for each of the trials were recorded to indicate (a) whether the infants examined the contents of the container by either looking inside or by inserting their hand into the container and (b) the latency to examine the contents of the container.

Each infant was seated in a child seat attached to a table facing the experimenter, and the parent was seated directly behind the child. The female experimenter wore a white T-shirt and had her hair tied in a ponytail to expose her eyes. In the warm-up phase, the infants in both the reliable and unreliable conditions observed the experimenter leaning forward toward the yellow container while asking, "What's in here?" Then, the experimenter shook the container, removed the lid, and tilted the container in order for the child to see the toy block inside. After closing the lid, the experimenter encouraged the child to open the container by saying, "Now, it's your turn." This was followed by an exploration period of 30 s during which the child could play with the container and examine its contents. A similar procedure was repeated for the training trials, except orange and blue containers were used and the containers were never shaken. Also, an exclamation ("Wow!") accompanied the experimenter's look inside the container along with a happy facial expression (i.e., raised eyebrows, open mouth in the shape of a smile). Each demonstration lasted approximately 10 s.

*True belief task.* This procedure was adapted from the one designed by Onishi and Baillargeon (2005) to examine whether 15-month-old infants were able to predict the experimenter's behavior on the basis of her true or false belief about a hidden toy's location. In the violation-of-expectation paradigm used in the present experiment, all infants completed three familiarization trials, one belief induction trial, and one test trial. The infant was seated facing the puppet theater, and the parent was seated next to the child. Prior to the administration of the true belief task, the experimenter raised the blinds to reveal herself. Then, she said, "Hello," and waved to the infant, to ensure that the infant recognized her, before putting on a white visor and closing the blinds. At the start of the first familiarization trial, the experimenter raised the blinds, grasped the cup, and played with it for a few seconds before hiding it inside the green box. The duration of this pretrial lasted 8 s. Once the cup was hidden, the experimenter paused with her hand inside the box and with her head tilted toward the hidden location, until the trial ended. A trial ended when the infant stared at the paused display for a maximum duration of 30 s or when the infant looked away from the display for more than 2 consecutive seconds after having looked at it for a minimum of 2 cumulative seconds. The blinds were lowered between trials. During the second and third familiarization trials, the experimenter reached into the box in which the cup was hidden in the pretrial portion of the trial. Then, she paused with her hand remaining inside the box until the trial ended.

In the belief induction trial, the infants observed as the experimenter leaned into the opening and watched as the cup slid along the ledge from the green box to the yellow box, resulting in a change of location. The cup moved along the ledge by means of a magnet placed underneath the ledge and aligned directly under the cup. The movement of the experimenter's arm and magnet beneath the ledge were concealed from the infant. This pretrial was followed by a pause, during which the experimenter maintained her tilted head toward the new object location.

Next, the infants received a test trial during which the experimenter reached into one of the two boxes. As a result, the experimenter searched for the cup in a location that was either consistent (congruent condition) or inconsistent (incongruent condition) with her belief about where it was hidden. The side on which the colored boxes appeared and the box in which the experimenter searched were counterbalanced across looker conditions.

### *Reliability*

An independent observer who was blind to the infant's experimental condition coded a random selection of 25% ($n = 16$) of the videotaped sessions to assess for interobserver reliability, with an equal number of participants selected from each group. A portion of the random selection ($n = 4$) included participants whose looking times at the congruent and incongruent search locations in the true belief task were zero, to determine the accuracy of the coding. We calculated mean interobserver reliability (Pearson product–moment correlations) for examination of containers and latency of examination for the search task: $r = .98$ (range = .86 to 1.00). In addition, $r = .99$ for the mean interobserver reliability for the looking time at the congruent and incongruent search locations, whereas $r = .97$ for the mean interobserver reliability for the looking time at the experimenter during the test trial. Finally, $r = .99$ (range = .97 to 1.00) for the mean interobserver reliability for the overall looking time at the display during the test trial.

## Results

To assess whether the infants from each group paid attention to the contents of the containers during the training task, we compared the number of times the infants examined the contents of the container during the training trials of the search task (out of 4 trials) in the reliable and unreliable looker conditions. The results indicated that the infants in both groups looked equally often inside the containers (reliable looker: $M = 3.91$, $SD = 0.29$; unreliable looker: $M = 3.67$, $SD = 0.56$), $t(47) = 1.85$, $p = .07$, $d = .34$. Also of interest was whether the infants developed an expectation about the content of the containers over time. Figure 1 shows infants' latency to examine the content of containers between the first and last trial of the training phase. We used an analysis of variance (ANOVA) with looker type (reliable, unreliable) as the between-subjects factor and trial (first trial, last trial) as a repeated measure. One would expect the infants who were misled by the experimenter in the search task (unreliable looker condition) to become gradually disinterested in the contents of the box. As expected, results revealed a significant interaction between trial and looker type, $F(1, 47) = 4.19$, $p < .05$, $\eta_p^2 = .08$. Pairwise comparisons with Bonferonni adjustments revealed that the infants in the unreliable looker condition took longer before examining the contents of the container in the last trial ($M = 11.17$ s, $SD = 10.75$) compared with the first training trial ($M = 5.13$ s, $SD = 5.29$, $p < .001$), whereas the infants in the reliable looker condition took equally long to examine contents in both trials (first trial: $M = 4.50$ s, $SD = 6.09$; fourth trial: $M = 5.13$ s, $SD = 6.46$ s, $p = .75$; see Figure 1). This outcome suggests that the infants in the unreliable looker condition learned that there was

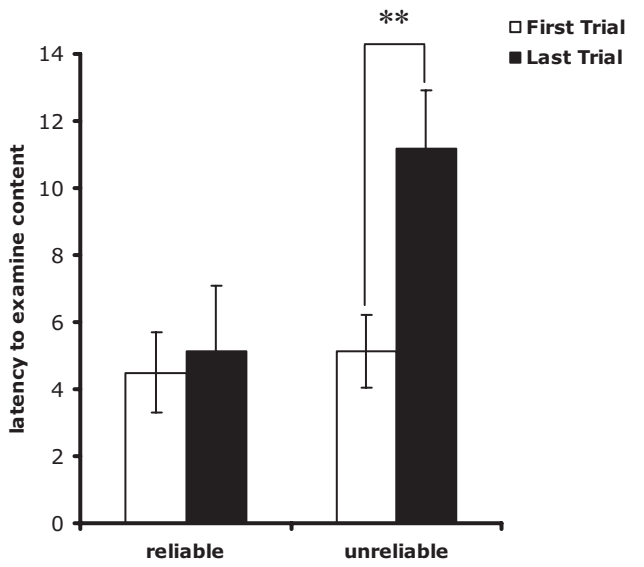


*Figure 1.* Mean latency (maximum = 30 s) to examine contents of container in first and last training trials for reliable and unreliable looker groups. Error bars show standard error of the means. ** $p < .001$.

nothing to look at inside the containers over trials and became disinterested in its contents after looking into an empty container repeatedly.

A series of three-way ANOVAs were conducted to examine whether the infants' prior experience with the experimenter's looking reliability during the training task influenced their subsequent reaction to the looker's search behavior in the true belief task. First, the infants' overall looking time at the event during the test trial was examined in a three-way ANOVA with gender, looker type (reliable, unreliable), and test condition (congruent, incongruent) as between-subject factors. Because no significant effects were found for gender, a subsequent two-way ANOVA using only looker type and test trial condition was conducted. As predicted, a significant interaction between type of looker and test trial condition was revealed, $F(1, 45) = 3.89$, $p < .05$, $\eta_p^2 = .08$ (see Figure 2). Pairwise comparisons with Bonferroni corrections revealed that the infants in the reliable looker condition looked longer at the incongruent display ($M = 8.46$ s, $SD = 7.43$) than at the congruent display ($M = 4.11$ s, $SD = 2.12$, $p < .05$), whereas the infants in the unreliable looker condition looked equally long at both displays (congruent: $M = 7.33$ s, $SD = 4.68$; incongruent: $M = 5.88$ s, $SD = 5.37$, $p = .46$). These findings suggest that 16-month-old infants take into account the past reliability of two people in a gaze-following task when they process their behavior in a belief attribution task.

To rule out the possibility that the infants in the unreliable looker group could have been inattentive to the experimenter's demonstrations during the familiarization trials because of their negative experience with her during the search task, we compared the average looking times across the three familiarization trials between the two looker groups. The results revealed that the infants' average looking time during the familiarization trials was similar across the two looker groups (reliable looker: $M = 9.66$ s, $SD = 4.08$; unreliable looker: $M = 9.38$ s, $SD = 6.00$), $t(47) = 0.19$, $p = .85$. Similar results were also found when we compared the infants' looking times during the induction trial between the two looker conditions (reliable looker: $M = 9.82$ s, $SD = 7.00$; unreliable looker: $M = 9.20$ s, $SD = 6.83$), $t(47) = 0.31$, $p = .76$, $d = .09$, and when we compared looking time at the experimenter during the test trial between the two looker groups (reliable looker: $M = 3.44$ s, $SD = 4.92$; unreliable looker: $M = 2.91$ s, $SD = 3.14$), $t(47) = 0.46$, $p = .65$, $d = .13$. In addition, we expected the infants in both looker groups to be equally attentive to where the experimenter was searching during the test trial. Therefore, looking times at each box during the test event, regardless of test trial condition (congruent, incongruent), was also examined in an ANOVA with looker type as a between-subject factor and search location (target box, non–target box) as a repeated measure. Results revealed a significant Search Location × Looker Type interaction, $F(1, 47) = 4.25$, $p < .05$. Pairwise comparisons with Bonferroni corrections revealed that the infants in both looker groups looked longer at the target box location (reliable: $M = 1.85$ s, $SD = 1.35$; unreliable: $M = 3.02$ s, $SD = 2.46$) than at the non–target box location (reliable: $M = 0.80$ s, $SD = 1.21$, $p < .05$; unreliable: $M = 0.71$ s, $SD = 1.04$, $p < .001$). However, infants in the unreliable looker condition looked longer at the target box ($M = 3.02$ s, $SD = 2.46$) than infants in the reliable looker condition ($M = 1.85$ s, $SD = 1.35$), $p < .05$. Overall, these findings suggest that the infants in the reliable and unreliable looker groups were equally interested in the key event in which the cup changed location. Thus, inattentiveness to the experimenter's actions could not account for the current pattern of results, which revealed that only the infants in the reliable looker group looked longer at the incongruent display when the experimenter reached for the cup in the incorrect location.

## Discussion

The present research reports evidence that 16-month-old infants respond differently to reliable and unreliable lookers and use their

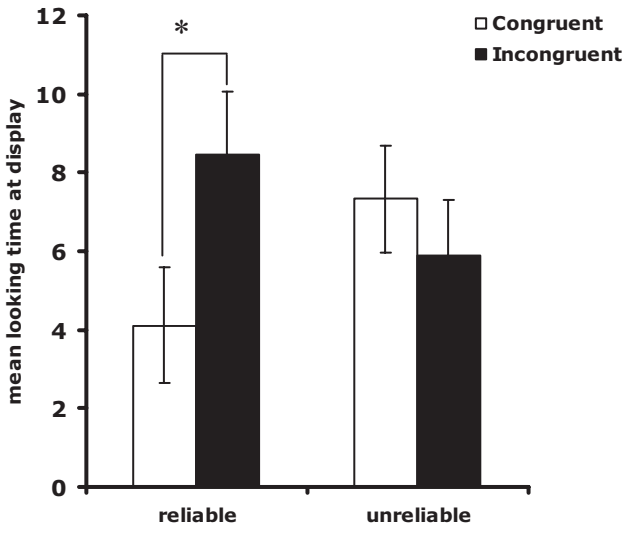


*Figure 2.* Mean looking time (maximum = 30 s) at display in congruent and incongruent test conditions for reliable and unreliable looker groups. Error bars show standard error of the means. * $p < .05$.

experience with the different lookers to subsequently judge their behaviors in a belief attribution task. In this study, the infants first observed an adult display positive affect (e.g., vocalization, smile) while looking inside a container that contained an attractive object (reliable looker) or was empty (unreliable looker). Although infants from both groups continued to look inside the container, those misled by the unreliable looker became gradually less motivated to verify the contents of the container, as evidenced by their increased latency to open the lid. This significant increase in latency over time provides evidence that the infants had developed mistrust toward the referential behaviors of the unreliable looker by the end of the training phase. The infants then watched the same experimenter act as the agent in a nonverbal true belief test (Onishi & Baillargeon, 2005). In this task, the infants were familiarized with the adult hiding and retrieving a toy (a cup) in one of two boxes. The looking times were computed on trials that tested whether the actor held a true belief about the location of the toy. As expected, the infants looked longer during the trials in which the adult searched in the wrong place when the same person had been a reliable looker in the previous search task (control condition). In contrast, the infants who had experienced an unreliable looker could not judge the accuracy of her search behavior and looked equally long at the correct and incorrect search. We speculate that the infants in the unreliable looker condition were able to encode and recall the inaccuracy of the looker's gaze during the search task and this knowledge influenced the processing of that looker's behavior in a different context.

One alternative interpretation for the present findings might be that the infants in the unreliable looker condition had become frustrated by the end of the search task as they kept having their expectations about the contents of the boxes violated. Consequently, their negative mood might have prevented them from fully processing the information provided during the true belief task. Similarly, they might have avoided looking at the person who had misled them in the past. We believe that this interpretation can be ruled out by the analysis of the induction trial, which was the trial during which the object changed location. An analysis of the infants' looking times during that critical trial revealed that the infants from both groups were equally attentive during that trial. Other evidence that infants were attentive to the actions of the experimenter regardless of her reliability record was the looking time pattern at the experimenter's hand during the test trials. In both groups, the infants paid more attention to the box in which the hand searched (box with the object in the congruent condition and empty box in the incongruent condition). Thus, inattention to the events involving the unreliable looker cannot explain the differential pattern of responses observed between the two groups.

We consider that there are two important implications of the present findings. First, our results corroborate and extend recently published findings suggesting that infants are sensitive to the belief states of other individuals (Onishi & Baillargeon, 2005; Poulin-Dubois et al., 2007; Surian et al., 2007). Our design, modeled after Onishi and Baillargeon's (2005), yielded the same pattern of results for the reliable looker condition (the default condition). More important, the present findings extend these striking findings by directly addressing the current debate over the alternative explanations that have been proposed for some form of belief understanding in infancy (e.g., Sirois & Jackson, 2007; Southgate et al., 2007; Surian et al., 2007). For example, it has been proposed that infants follow a simple rule according to which agents tend to search in places where they last saw things (Perner & Ruffman, 2005). In other words, there is no need to assume an understanding on the infant's part that a mind mediates the actor's behaviors. We believe that the current findings cannot be easily explained by such a rule-based explanation. Why would the past record of reliability hinder the online prediction that the agent should look for the object at the last place she saw the object? In other words, if the rule-based explanation applied, then the infants in the unreliable looker group would be demonstrating the same looking time pattern during the test trial as the infants in the reliable looker condition. Furthermore, the infants tended to look at the agent when she performed an incongruent action, but only if the agent had a past record of reliability. This suggests that the infants tried to understand the nature of the incongruent action, supporting a rich interpretation of the looking behaviors.

The second implication of our experiment is the demonstration that infants can appraise the reliability of others and encode the identity of an unreliable person. Furthermore, they can generalize their knowledge about a person's unreliable behavior across different contexts in which the person's gaze is involved. Until recently, only preschoolers had been shown to expect that individuals who have proved inaccurate in the past would prove inaccurate in the future (Harris, 2007). In a recent experiment, Chow et al. (2008) showed that 14-month-old infants are more likely to follow the gaze of a person if her gaze was reliable in a previous task in which she looked inside boxes with excitement. The present study extends these findings by demonstrating infants' ability to make a broad assessment of someone's epistemic reliability. This was revealed by the fact that the infants judged the unreliable looker's incorrect search behavior to be equally plausible to a correct search behavior, even if they had no access to the gaze of the agent in the belief task (eyes covered with a visor), except at the onset of the task.

In future research, it will be important to examine the scope of infants' ability to develop epistemic trust. An important question is whether epistemic reliability will influence infants' willingness to learn new information from an individual. For example, infants might refuse to imitate an unreliable person or might not be inclined to imitate what appear to be irrational actions (Gergely, Bekkering, & Király, 2002; Meltzoff, 1988). Another important question to explore is the potential link between emotional and epistemic reliability (Harris, 2007). Would infants generalize the epistemic unreliability of an adult to the emotional domain? For example, one might wonder if infants would use the emotional cues (social referencing) of an unreliable adult when appraising an uncertain event.

In conclusion, the present study adds to the growing number of studies that show that early in the 2nd year, infants reach important milestones in their understanding of human behavior. The ability to predict future behaviors based on a person's previous visual contact with an event develops early during the 2nd year of life, with an important transition between 14 and 18 months of age (Liszkowski, Carpenter, & Tomasello, 2008; Luo & Baillargeon, 2007; Poulin-Dubois et al., 2007; Sodian & Thoermer, 2008). Our findings add an important milestone in this development by showing that infants register and recall readily what a specific person is experiencing when she looks referentially at objects and develop

expectations about her future actions based on the credibility of her referential behaviors.

## References


Carlson, S. M., Molson, L. J., & Hix, H. R. (1998). The role of inhibitory control in young children's difficulties with deception and false belief. *Child Development, 69,* 672–691.

Chow, V., Poulin-Dubois, D., & Lewis, J. (2008). To see or not to see: Infants prefer to follow the gaze of a reliable looker. *Developmental Science, 11,* 761–770.

Clément, F., Koenig, M., & Harris, P. (2004). The ontogenesis of trust. *Mind and Language, 19,* 360–379.

Csibra, G., & Southgate, V. (2006). Evidence for infants' understanding of false beliefs should not be dismissed. *Trends in Cognitive Sciences, 10,* 4–5.

Gergely, G., Bekkering, H., & Király, I. (2002). Rational imitation in preverbal infants. *Nature, 415,* 6873.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3½–7 years old on a Stroop-like day-night test. *Cognition, 53,* 129–153.

Gomez, J. C. (2004). *Apes, monkeys, children, and the growth of mind.* Cambridge, MA: Harvard University Press.

Harris, P. L. (2007). Trust. *Developmental Science, 10,* 135–138.

Hood, B. M. (1995). Gravity rules for 2- to 4-year-olds? *Cognitive Development, 10,* 577–598.

Koenig, M., Clément, F., & Harris, P. L. (2004). Trust in testimony: Children's use of true and false statements. *Psychological Science, 15,* 694–698.

Leslie, A. M., German, T. P., & Polizzi, P. (2005). Belief-desire reasoning as a process of selection. *Cognitive Psychology, 50,* 45–85.

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

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.

Meltzoff, A. N. (1988). Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology, 24,* 470–476.

Miller, C. A. (2001). False belief understanding in children with specific language impairment. *Journal of Communication Disorders, 34,* 73–86.

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

Perner, J., & Ruffman, T. (2005). Infants' insight into the mind: How deep? *Science, 308,* 214–216.

Poulin-Dubois, D., Sodian, B., Metz, U., Tilden, J., & Schoeppner, B. (2007). Out of sight is not out of mind: Developmental changes in infants' understanding of visual perception during the second year. *Journal of Cognition and Development, 8,* 401–425.

Repacholi, B. M. (1998). Infants' use of attentional cues to identify the referent of another person's emotional expression. *Developmental Psychology, 34,* 1017–1025.

Sabbagh, M. A., & Baldwin, D. A. (2001). Learning words from knowledgeable versus ignorant speakers: Links between preschoolers' theory of mind and semantic development. *Child Development, 72,* 1054–1070.

Sirois, S., & Jackson, I. (2007). Social cognition in infancy: A critical review of research on higher order abilities. *European Journal of Developmental Psychology, 4,* 46–64.

Sodian, B., & Thoermer, C. (2008). Precursors to a theory of mind in infancy: Perspectives for research on autism. *The Quarterly Journal of Experimental Psychology, 61,* 27–39.

Song, H. J., 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.

Southgate, V., Senju, A., & Csibra, G. (2007). Action anticipation through attribution of false belief by 2-year-olds. *Psychological Science, 18,* 587–592.

Surian, L., Caldi, S., & Sperber, D. (2007). Attribution of beliefs by 13-month-old infants. *Psychological Science, 18,* 580–586.

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development, 72,* 655–684.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13,* 103–128.

Zelazo, P. D., Frye, D., & Rapus, T. (1996). An age-related dissociation between knowing rules and using them. *Cognitive Development, 11,* 37–63.


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