A Matter of Trust: The Influence of a Looker's Past Reliability on Infants' Gaze Following and Reasoning About Beliefs

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ABSTRACT

A Matter of Trust: The Influence of a Looker's Past Reliability on Infants' Gaze Following and Reasoning About Beliefs

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The objective of the present thesis was to examine infants' understanding of other people's mental states, such as visual perception and beliefs. The first paper was designed to systematically investigate whether 14-month-olds would follow the gaze of a person to a target hidden behind a barrier when the person's perception was previously unreliable. Infants were first trained on a search task to either expect a person's gaze to be either reliable or unreliable. Then, their gaze following behavior was observed in a gaze following task during which an experimenter looked at a target in front (control condition) and in back of a barrier (experimental condition). In Study 1, infants were more likely to follow the gaze of the reliable looker than infants in the unreliable looker group. In contrast, no differences in gaze following were observed across groups in the control condition. In study 2, when a naïve experimenter administered the gaze following task following training with an unreliable looker in the search task, infants treated the naïve experimenter as though she was a reliable looker and were more likely to follow her gaze behind the barrier than infants in the unreliable looker group in the first study.

In the second paper, infants' ability to generalize their knowledge about the reliability of a person's gaze to another context was explored. This paper examined whether 16-month-olds' past experience with the reliability of what a person sees influences their expectation regarding where the person should look for a toy that was previously hidden. Results showed that only infants in the reliable looker group were

surprised and therefore looked longer when the experimenter searched for the hidden toy in the incorrect location as compared to the correct location; whereas infants who were previously exposed to an unreliable looker looked equally long at both search locations. Taken together, these results demonstrate for the first time that infants as young as 14 months of age encode the identity of a person based on their past gaze reliability and use this information to decide whether or not to follow her gaze and implicitly attribute beliefs.

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CONTRIBUTIONS OF AUTHORS

This Ph.D. consists of two manuscripts.

Study 1 and Study 2 (See Chapter 2)

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Study 3 (See Chapter 3)

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Relative Contributions

I proposed the overall research topic and in collaboration with Dr. Poulin-Dubois, the thesis supervisor, we determined the focus of each study. I also worked closely with Dr. Poulin-Dubois on creating the experimental stimuli, outlining the method and design for all three studies. Prior to testing, I prepared and sent recruitment letters to participants. Then, Tanya Malka and I both called participants for recruitment for all three studies. In preparation for testing, I produced detailed scripts describing the action sequences and/or live demonstrations to be used during testing. With respect to data collection, I tested the entire sample for the first study. Alla Sorokin, a research assistant, and Jessica Lewis, an undergraduate student, helped with data collection for Experiment 2 as part of Jessica Lewis' undergraduate thesis. I was responsible for testing 50% of participants in the second study. Additionally, I coded 100% of infants' responses for the search task and barrier task in the first two studies. Two research assistants, Amanda Guay and Alexandra Polonia helped with the data collection in study 3. I was responsible for testing approximately 86% of participants in study 3. I coded the responses of the

infants I had tested for the search task and true belief task. Following completion of the studies, I was responsible for the data entry, statistical analyses, interpretation of the data, and preparation of the manuscripts. For each manuscript, I wrote the first draft of each section and Dr. Poulin-Dubois provided feedback and revisions. After each study, I described the research findings in our laboratory's newsletter and sent it with thanks to the families who participated in our studies. Dr. Poulin-Dubois was available at all stages of research, particularly in research design, manuscript preparation, and for consultation and feedback.

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Chapter 1

Introduction

As adults, we understand others as intentional beings and attribute to one another internal mental states, such as beliefs, perception, intentions, and desires. This human capacity for reasoning about others' mental states is referred to as folk psychology (also known as "theory of mind" and/or naïve psychology); an ability that helps us to reason about the causes and predict another person's behavior (Premack & Woodruff, 1978), communicate referentially (Dunphy-Lelii & Wellman, 2004), and interpret jokes or sarcasm (Leekam, 1991). This ability is so critical in fact, that its absence is thought by some to be a central cause of autism (e.g., Baron-Cohen, 1995). Consider a situation in which a person is looking inside a cookie jar. We may attribute to this person a number of different mental states, including beliefs (e.g., She *thinks* there are still cookies in the jar), desires (e.g., She *wants* to have a cookie) and intentions (e.g., She *intends* to find a cookie by searching in the jar). Given the importance of folk psychology in human social and cognitive life, developmental and cognitive psychologists have pondered about when and how children develop everyday knowledge about their own and others' mental states.

Different theories of cognitive development have been offered to explain the developmental origins of adults' ability to attribute mental states to others. According to one account of early psychological reasoning, infants are born with a psychological reasoning system that provides them with a shallow framework for interpreting the intentional actions of agents in terms of mental states (adapted from Leslie, 1987, 1995, 2000; see also Johnson, 2000, 2003; Luo & Baillargeon, 2007; Premack, 1990; Song & Baillargeon, 2008; Song, Onishi, Baillargeon, & Fisher, 2008). This system is thought to

be composed of two subsystems. When a child observes an agent act on objects in a setting, the first subsystem allows them to attribute motivational states and reality-congruent information states. Motivational states refer to an agent's motivation in a scene, such as dispositions and goals, and reality-congruent informational states refers to the accurate information an agent possesses or lacks in a scene, such as perceptions and beliefs (Gergely, Nádasdy, Csibra, & Bíró, 1995; Kuhlmeier, Wynn, & Bloom, 2003; Leslie, 1994; Premack, 1990; Song et al., 2005; Woodward, 1998).

The second subsystem extends from the first, which allows the child to attribute reality-incongruent informational states to the agent. That is, the child is able to take into account information about the setting that deviates from reality in that it is false or pretend (e.g., Leslie, 1987; Onishi, Baillargeon, & Leslie, 2007). To attribute a reality-incongruent state to an agent, the child must be able to hold in mind two distinct versions of the setting: one that corresponds to reality (as they construe it) and another that corresponds to the agent's false representation (e.g., Leslie, 1994).

Current evidence suggests that the first subsystem is operational in the first months of life whereby even young infants can attribute dispositions and goals to others (e.g., Csibra, 2008; Hamlin, Wynn, & Bloom, 2007; Johnson, OK, & Luo, 2007; Song & Baillargeon, 2007; Woodward, 1998). For example, after watching an agent repeatedly reach for object A as opposed to object B in a setting, 5-month-olds attribute to the agent a preference for object A over B. When the objects' positions are reversed, infants expect the agent to reach for object A in its new position and look reliably longer in response to the agent's goal change when she reaches for object B instead (Luo & Baillargeon, 2005; Woodward, 1998).

Similarly, research on reality-congruent information states suggest that, by the end of the first year, infants are able to keep track of objects an agent can or cannot see and are able to interpret their actions accordingly (e.g., Brooks & Meltzoff, 2005; Caron, Kiel, Dayton, & Butler, 2002; Luo & Baillargeon, 2007; Tomasello & Haberl, 2003). For instance, when 12.5-month-olds watch an agent repeatedly reach for object A over object B, they do not attribute to the agent a preference for object A if object B is hidden from the agent by a screen. However, they do attribute such a preference if the agent is aware that object B is hidden behind the screen because the agent witnessed its placement earlier (Luo & Baillargeon, 2007).

In contrast, studies that have focused on reality-incongruent informational states, such as the use of false belief tasks (see below for description) have generally assumed that this ability does not emerge until 4 years of age (e.g., Perner, 1995; Wellman, Cross, & Watson, 2001). Taken together, research on infants' ability to attribute mental states to agents provide strong evidence for the notion that theory of mind develops gradually. Consequently, most cognitive developmental scientists now emphasize a developmental perspective when studying theory of mind (e.g., Sodian & Thoermer, 2008; Wellman & Lagattuta, 2000).

Over the past 20 years, research on theory of mind has focused on whether children can interpret and predict an agent's actions as a function of what they see and the content of their beliefs. A common task used to test children's ability to explain an action with reference to the agent's belief is the "false belief" task (Wimmer & Perner, 1983). In a standard version of this task, a child is told a story in which a character's belief about the location of a target object becomes false when the object is moved without the character's

knowledge. For instance, in Wimmer and Perner's original version of the task, children are told that Maxi puts his chocolate in the green cupboard and then goes out to play. While he is away (and cannot see), his mother moves the chocolate from the green cupboard to the blue cupboard. Then, the children are asked to predict Maxi's actions by responding to the questions, "Where does Maxi *think* the chocolate is?" and, "Where will Maxi *look* for the chocolate?" It is only at the age of 4 years that children succeed on this task by correctly judging that Maxi will look for the chocolate in the green cupboard; thus taking into account the actor's belief when it diverges from reality. As such, Wellman, Cross, and Watson (2001) have proposed that infants younger than 4 years of age, who have been shown to repeatedly fail the standard false belief task, lack a "theory of mind." Consequently, researchers have postulated that children's understanding of others as mental agents undergoes a conceptual change around age 4 (e.g., Perner & Ruffman, 2005). Although various versions of the classic false belief task have been created and the precise age of success varies as a function of task demands (e.g., Carlson, Moses, & Hix, 1998; Surian & Leslie, 1999), generally, children younger than 3 or 4 do not correctly solve false belief problems. For instance, 3-year-olds are successful on false belief tasks when more explicit test questions are used instead of standard ones (e.g., Siegal & Beattie, 1991; Surian & Leslie, 1999; Yazdi, German, Defeyter, & Siegal, 2006) whereas children younger than 2 years 11 months fail to correctly anticipate the behavior of a person with a false belief using a predictive looking paradigm (Clements & Perner, 1994).

Despite the consistent pattern of findings with 4-year-olds' performance on standard false belief tasks, there are reasons to be cautious with the results. First, succeeding on

the false belief task may require more than a conceptual understanding of other people's beliefs (Bloom & German, 2000). That is, a correct answer entails more than an understanding that people think and act according to the way they represent the world mentally rather than the way the world actually is. Rather, it is possible, for example, that younger children may understand the concept of belief but that their performance is masked by immaturity in other cognitive abilities that are necessary for success on the task. For example, in order to provide the correct response, a child must be able to juggle two competing representations of reality (where Maxi believes the cookies are stored and where the cookies are in reality) and inhibit the incorrect response regarding the reality of the situation. In addition, children's performance on the false belief task may also depend on exposure to family talk about mentalistic explanations for a person's action. In fact, inhibitory control and some aspects of syntactic knowledge are both correlated with false belief task performance (Astington & Jenkins, 1995; 1999; Carlson & Moses, 2001; de Villiers & Pyers, 2002; Watson, Painter, & Bornstein, 2001). As such, when demands on inhibitory control were reduced in modified versions of the false belief task, improvements were noted in even 2- and 3-year-olds' performance (Clements & Perner, 1994; Garnham & Ruffman, 2001). A second reason for treating the results from the false belief task with caution is that there is more to belief understanding than succeeding on the false belief task. That is, adults' and children's everyday reasoning about other people's theories of mind depends on attributions of mostly true beliefs and rational actions (Bartsch & Wellman, 1995; Dennett, 1996). For these reasons, the false belief task is at best a limited tool for examining infants' understanding of folk psychology.

Recent research based on spontaneous speech and experimental paradigms, such as violation of expectation and eye tracking, has revealed that even young children have some form of folk psychology (e.g., Bartsch & Wellman, 1995) whereby 2- and 3-year-olds engage in a host of behaviors that ostensibly entail the attribution of mental states to other individuals. They readily deceive and lie (Chandler, Fritz, & Hala, 1989; Dunn, 1991; Newton, Reddy, & Bull, 2000), imitate intended actions (Carpenter, Akhtar, & Tomasello, 1998; Meltzoff, 1995), initiate and engage in pretend play with others (Leslie, 1994), and distinguish between intentional from non-purposeful actions, such as accidents or movements due to reflexes or gravity (Call & Tomasello, 1998; Shultz & Wellman, 1997; Shultz, 1990). In one of the most convincing examples of mental-state attributions, two-year-olds adapted their communicative gestures to a desired toy depending on whether or not their parents witnessed the toy being placed out of reach on a shelf. This suggests that 2-year-olds have an ability to modify their behavior depending on the knowledge state of others (O'Neil, 1996).

Evidence that preschoolers possess some understanding of others' mental states has spurred researchers to uncover whether even younger children or infants show some implicit understanding of mental states as evidenced by the emergence of explicitly mentalistic vocabulary such as "want" and "see" (Bartsch & Wellman, 1995). Two types of mental state attribution that have received considerable empirical investigation have been visual perception and belief understanding. Attributing visual perception refers to the understanding that others may have visual perspectives that are different from their own, whereas attributing beliefs refers to the psychological state in which a person holds

a proposition or premise to be true (e.g., He looked inside the cookie jar and therefore knows if there are any cookies left).

The reasons for focusing on visual perception is because a person's eyes (1) are observable to infants, (2) provide important information about the target of a person's mental attention and thus his or her underlying mental states and (3) and help one to identify and share attention for the purposes of communication (Dunphy-Lelii & Wellman, 2004; Senju, Johnson, & Csibra, 2006). Thus, understanding the referential nature of gaze may be a precursor for the development of full fledged folk psychology whereby individuals construe other people in terms of their internal psychological states, such as desires, beliefs, and intentions (Wellman, Phillips, & Rodriguez, 2000).

Infants' understanding of visual perception has typically been researched by examining their understanding of gaze direction as evidenced by their gaze following; that is, looking where someone else is looking. From an early age, infants show sensitivity to other people's eyes. For instance, infants as young as 2 months show preferential attention to eyes over other facial features (Caron, Caron, Caldwell, & Weiss, 1973; Haith, Bergman, & Moore, 1977; Maurer & Salapatek, 1976), respond to shifts in gaze direction (Hains & Muir, 1996; Symons, Hains, & Muir, 1998) and 3-month-olds show a preference for female adult faces with eyes open than with eyes closed (Batki, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000). Given infants' early sensitivity to a person's eyes and their ability to follow gaze, researchers have proposed that gaze following may represent one of the potential building blocks or precursors to developing a theory of mind (Dunphy-Lelii & Wellman, 2004).

Although many studies have demonstrated that infants show an early sensitivity to a person's eyes, a question that arises is when do children possess a genuinely psychological concept of perception? That is, at what age do infants understand the referential nature of looking, which entails understanding the relationship between a person's eyes and an object? According to Povinelli and Eddy (1996), knowledge about visual perception could be processed at three different levels. At the first level (Level-1 visual perspective taking), it is possible for individuals to attend and respond to another person's eyes without understanding anything about their significance or function. According to this view, an infant may follow a person's gaze without attributing to the person any mental states. The widespread sensitivity to the presence of eyes in a variety of species, including birds, fish, reptiles, and mammals (e.g., Burger, Gochfeld, & Murray, 1991; Gallup, Nash, & Ellison, 1971; Ristau, 1991) suggests that this sensitivity in early human development may serve as an evolutionarily adaptive ability and does not constitute unique evidence that infants understand the mentalistic properties of visual perception (Povinelli & Eddy, 1996).

A second level (Level-2) by which individuals could understand visual perception is that the person could appreciate vision as an attention focus that subjectively connects individuals to the world (Povinelli & Eddy, 1996). At this level of processing, the person understands that vision has the effect of focusing one's subjective attention on specific aspects in the environment. A series of recent studies provide evidence that 12- to 14-month-old infants interpret gaze as directed *at* something (e.g., Brooks & Meltzoff, 2002; Caron, Butler, & Brooks, 2002; Moll & Tomasello, 2004). For example, Brooks and Meltzoff (2005; cited in Meltzoff & Brooks, 2007) adapted Woodward's paradigm from

goal-directed actions to measure referential understanding of perception. Ten-month-old infants were habituated to an adult, with either open or closed eyes, who turned toward one of two objects. When the position of the objects was switched at the test phase, the infants looked longer if the adult now looked at the old location (new object) than if the adult looked to the new location (old object). This pattern of findings was true only if the adult's eyes were open during habituation, suggesting that the infants understood that looking, but not head-turning, is object-directed. While infants early in their second year of life appear to understand perception as referential, it is probably not representational; a characteristic of the final level (Level-3) of visual perception understanding whereby people understand the role that visual perception plays in creating internal, unobservable mental states (e.g., knowledge or belief).

However, results from studies on gaze following have fuelled a contentious debate concerning how to interpret infants' gaze following actions and his/her attributions about the looker. In fact, findings from studies on gaze following in infancy are open to both rich and lean interpretations. According to the rich interpretation, infants understand seeing as a mental state providing the actor visual access and knowledge about the world (Butler, Caron, & Brooks, 2000; Moll & Tomasello, 2004). In contrast, the lean account argues that gaze following does not demonstrate any mentalistic understanding. Rather, the tendency of infants to follow gaze could depend on a learned association between the direction of adult gaze and interesting events in the world, or be due to a hard-wired reflex (Csibra & Volein, 2008; Moore & Corkum, 1994; Corkum & Moore, 1995; Moore, 2006). For example, results from Dunphy-Lelii and Wellman's study (2004) showed that 14-month-olds were significantly more likely to follow a

person's gaze to a target in a transparent barrier condition than with an opaque barrier condition. These findings could be interpreted in one of two ways: One alternative is that infants at this age understand the referential nature of looking, thus supporting the richer account. A second alternative is that infants may have simply used the person's eyes as a predictive cue to follow her gaze to the target in the transparent barrier condition that involves no understanding of her attention or reference to the target.

With respect to belief understanding, a growing body of research has indicated that infants below the age of 4 years possess an implicit understanding of knowledge and belief. In particular, a landmark study conducted by 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 toy's hidden location. Using a nonverbal false belief task, Onishi and Baillargeon familiarized 15-month-old infants to an event that involved an agent hiding a toy in one of two boxes. Next, they observed as the adult either witnessed or did not witness the change in the toy's location. Interestingly, infants who saw the adult witness the change of location were surprised and therefore looked longer when she searched for the toy in the incorrect location as compared to the correct location. The opposite pattern was true when infants observed the adult, who did not witness the change of location, search in the correct location. These results suggest that infants expected the adult to search for the object in the location based on her knowledge of where she had seen it previously, regardless of the toy's true location. Consistent with these findings, Southgate, Senju, and Csibra (2007) found that 25-month-old 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 toy's true

hidden location and correctly predict the behavior of the agent in terms of his or her false belief. Likewise, a looking time study demonstrated that 13-month-old infants predict 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 (Surian, Calder, & Sperber, 2007). Furthermore, using a preferential looking paradigm, Poulin-Dubois, Sodian, Metz, Tilden, and Schöppner (2004) found that by 18 months of age, infants appear to encode not only what another person sees or does not see, but also infer subsequent correct or incorrect action from a person's access to information.

In short, these results show that infants demonstrate an implicit understanding of where an actor should search for a toy based on her knowledge about its hidden location. At the same time, these results call into question the notion that only 4- or 5-year-olds have undergone a conceptual change and possess a representational theory of mind; that is, they understand that others act on the basis of their beliefs, which may or may not mirror reality. It may be that infants have simply 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 (Ruffman & Perner, 2005). To support this parsimonious explanation, Corkum and Moore (1998) demonstrated that 8- to 9-month-olds' gaze following can be partially shaped by conditioning when they do not follow gaze spontaneously. A similar associative response has also come from studies that demonstrate that even rats exhibit a differential activation of neurons when exposed to a new arrangement of familiar stimuli as compared to a familiar arrangement. This suggests that an increase in looking time from infant studies could result from an increase

of firing from neurons that code for the recency of stimuli exposure and not because infants have any knowledge about the mental states that mediate behavior (Wan, Aggleton, & Brown, 1999).

One way to clarify the depth of infants' understanding of visual perception and beliefs is by contrasting their gaze following and belief attribution in response to a person whose gaze is either reliable (trustworthy) or unreliable (untrustworthy). If infants understand gaze and beliefs as being subjective, they will adapt their gaze following behavior and belief attribution based on their understanding that a person's perceptual access influences her perception and knowledge state. Therefore, if infants are simply following gaze due to a learned association, infants will follow a person's gaze regardless of her reliability status. On the other hand, if infants are able to take into account the subjectivity of gaze depending on whether they trust what the person sees, then they should modify their gaze following behavior. According to Moore (2006), this subjective understanding of gaze may represent an important developmental (and perhaps phylogenetic) step in gaze understanding that entails understanding gaze as subjective without any mentalistic attributions. For example, I may see an object that you may not, given the barrier between the object and me.

However, if infants are simply looking longer at the location that is inconsistent with the actor's belief due to low-level strategies (following a behavioral rule), then infants who have been exposed to the reliable and unreliable looker would look longer at the test event featuring an actor searching for the target in the wrong location. In contrast, if infants take into account the past reliability of a person's gaze, then they may infer that her gaze is also unreliable in the new context and therefore suspend any attribution of

belief regarding where she will search for the toy that she has previously hidden, resulting in equal looking times at the test events where the actor searches for the target in the correct or incorrect location. Therefore, if infants can distinguish between their own and the actor's perception and use the actor's perception (rather than their own) to predict the actor's subsequent search behavior, then a stronger argument could be made in favor of infants' subjective understanding of other people's beliefs.

Reliability of a looker represents a novel method by which to explore infants' understanding of the referential nature of gaze. Importantly, the contrast between the two lookers whose credibility varies permits the examination of whether infants can hold in memory two different representations of what a person sees and to make a judgment about whose gaze is referential. As a result, this method of examining perception understanding can inform us about how children come to understand that individual differences in perceptual access result in differences in knowledge.

To date, research on trust has focused predominantly on preschooler's acceptance of adult testimony in the domain of word learning and object labeling (Clement, Koenig, & Harris, 2004; Koenig, Clement, & Harris, 2004; Sabbagh & Baldwin, 2001). For example, when presented with two informants, one who provides consistently accurate names, 4-year-olds prefer the names offered by the reliable informant to label new objects (Clement et al., 2004; Koenig et al., 2004). Other research has shown that three-year-olds learn new words from confident rather than uncertain speakers (Sabbagh & Baldwin, 2001). Furthermore, Koenig and Echols (2003) found that 16-month-old infants were prone to look inquisitively at an informant who misnamed a familiar object whereas they typically looked at the referent following accurate naming. Outside the domain of

word learning and object labeling, preschoolers favored someone who was previously accurate about the typical functions for common objects over someone who was previously inaccurate (Birch, Vauthier, & Bloom, 2008). Taken together, these findings suggest that preschoolers are able to encode the identity of individuals when deciding whom to trust for new information and can adapt their learning and behavior accordingly. However, it remains to be determined whether infants could similarly encode the credibility of an informant and whether they will adapt their gaze following depending on the informant's past reliability with gaze.

The first paper of the present dissertation sought to address this issue by comparing infants' gaze following in response to a person whose gaze is either reliable or unreliable. Following a training phase whereby infants develop an expectation about the reliability of the adult's gaze, 14-month-old infants' attribution of what a person sees was then explored by examining their gaze following behavior to a target visible in front of a barrier and to a target hidden behind a barrier as a function of the type of looker (reliable and unreliable). Results from this study provided evidence of the youngest age group to date to be able to encode the reliability of the informant's gaze and to be able to generalize their knowledge about the accuracy of the person's gaze from one context (search task) to another (gaze following) task. These results also provide empirical support that 14-month-olds have a Level-2 understanding of visual perception whereby infants could appreciate that a reliable person's gaze is referential and an unreliable person's gaze is not.

The second paper in this dissertation focused on belief understanding, another aspect of folk psychology. The objective of this paper was to determine whether past

experience with the reliability of an adult's gaze would influence 16-month-old infants' judgment concerning the adult's ability to acquire knowledge from visual experience (attribution of true belief). Results from this study revealed that 16-month-olds were able to use their knowledge about the reliability of a person's gaze to predict where they believe the person should search for the hidden object. Furthermore, these findings extend those from the first paper by demonstrating that infants can generalize and track the reliability of the looker not only across similar contexts (e.g., search and gaze following tasks both share the component of the experimenter looking at an unseen target followed by the infant's gaze following) but also across different theory of mind tasks (i.e., a task designed to examine infants' understanding of gaze versus belief). Collectively, these findings will inform researchers regarding infants' ability to attribute mental states to others and to clarify whether their performance on the search task and true belief task is due to low-level strategies, such as following a learned association, or due to their referential understanding of another person's gaze. In addition, these findings will also inform researchers about the scope of infants' epistemic trust toward an informant. It may be plausible to expect that individuals whose gaze proved reliable in the past will also prove reliable in the future in other contexts.

Chapter 2

To See or Not to See: Infants Prefer to Follow the Gaze of a Reliable Looker

To see or not to see: Infants prefer to follow the gaze of a reliable looker

Gaze following occurs when one person focuses his/her visual attention to where another person is looking. The ability to follow the gaze direction of others is considered a critical component in social interactions (Argyle & Cook, 1976; Kleinke, 1986; Langton, Watt, & Bruce, 2000) and is posited as a developmental precursor to children's later theory of mind abilities (e.g., Corkum & Moore, 1998). The capacity to follow another person's line of sight is relevant to a number of abilities including understanding the meaning of an emotional display (Moses, Baldwin, Rosicky, & Tidball, 2001; Repacholi, 1998), language acquisition (Baldwin, 1995; Bloom, 2002; Tomasello, 1995), and inferring a range of mental states that include intentions, beliefs, and desires (Baldwin & Moses, 1994; Lee, Eskritt, Symons, & Muir, 1998; Meltzoff & Brooks, 2001, Onishi & Baillargeon, 2005). The importance of gaze following as a developmental milestone can be inferred from the case of children with autism. Specifically, autistic children often lack the ability to use gaze direction as a cue to understand a speaker's referential intent (Baron-Cohen, Baldwin, & Crowson, 1997).

Research on infants' ability to follow the gaze direction of others has revealed that from 3 months of age, infants can follow gaze to a highly visible object that is within their immediate visual field (Caron, Caron, Roberts, & Brooks, 1997; D'Entremont, 2000; D'Entremont, Hains, & Muir, 1997) and later, at 12 months of age, to targets outside their visual field (Carpenter, Nagell, & Tomasello, 1998; Moll & Tomasello, 2004; Morissette, Ricard, & Gouin-Décarie, 1995). However, there is a raging debate in the literature concerning the meaning of infants' gaze following and whether it should be necessarily construed as being mentalistic. Specifically, there is uncertainty as to whether

infants understand adults' looking as directing their attention towards an object in the environment (Bretherton, 1991; Baron-Cohen, 1995; Carpenter, Nagell, & Tomasello, 1998; Caron, Kiel, Dayton, & Butler, 2002) or whether infant's attention is drawn to a location as a result of a built-in orienting response (Langton, Watt, & Bruce, 2000; Moore & Corkum, 1994; Moore, 1999; Povinelli, 2001).

Experimental studies that have provided support for a "richer" or mentalistic interpretation have typically used one of two basic experimental paradigms to demonstrate that infants understand the link between visual perception and objects in the environment. First, the Eye Status paradigm has been used wherein a person systematically moves just his/her eyes, head, or both toward an object in order to identify the cues that elicit gaze following in infants. Using this approach, evidence suggests that it is not until 18 to 19 months that infants are able to follow gaze on the basis of eye movement (head remains frontal; Corkum & Moore, 1995; Moore & Corkum, 1998). However, a recent ERP study has reported the encoding of gaze-object relations on the basis of gaze alone in 9-month-old infants (Senju, Johnson, & Csibra, 2006). Before this age, when head and eye movements are discordant (head and eyes turn in different directions), infants seem more inclined to follow the head direction than the eye direction (Corkum & Moore, 1998; Caron, Butler, & Brooks, 2002). For example, 15- to 16-month-olds are equally likely to follow a head turn alone (with eyes frontal) as they are to follow both a head and eye turn (Corkum & Moore, 1998). To eliminate the presence of conflicting head and eye cues, infants' gaze following was explored when a person's head turn was accompanied by eyes that were either opened or closed (Brooks & Meltzoff, 2002, 2005; Caron, Kiel, Dayton, & Butler, 2002; Dunphy-Lelii & Wellman,

2004). Results revealed that infants as young as 10 months were more likely to follow gaze in the opened eye condition. However, when blindfolded eyes were substituted for the closed eye condition in a follow-up study, Brooks and Meltzoff (2002) found that 14- and 18-month-olds, but not 12-month-olds, followed gaze more in the opened eyes condition, whereas D'Entremont and Morgan (in press) indeed found the same pattern of results for 12- to 13-month-olds. On the basis of these findings, authors have concluded that infants as young as 10 months of age are sensitive to the status of the adult's eyes and their reference to external targets (Meltzoff & Brooks, 2007).

The Barrier paradigm is the second experimental paradigm that has been used to examine gaze following when an obstacle blocks the person's line of sight to a target. For example, a study by Butler, Caron, and Brooks (2000) found that 14- and 18-month-olds were more likely to follow an experimenter's gaze to a target when her line of sight was clear than when it was blocked by an opaque screen. However, once the presence of the screen was controlled for, and an additional condition of a screen with a window was used, 18- (but not 14-month-olds) followed gaze direction in the window condition as much as in the condition without the screen, thus indicating that the understanding of the requirement of a clear line of sight develops somewhere between 14- and 18-months of age. In a follow-up study with 12- and 15-month-olds, only the 15-month-old infants showed understanding of line-of-sight requirements when combining pointing and turning (Caron et al., 2002). In contrast, the 12-month-olds construed neither pointing nor looking as referential behaviors in the presence of barriers. To reduce the limitation of having a barrier so close to the looker, which may create an unusual situation, Moll and Tomasello (2004) recently used a variation of this paradigm to create a more natural

situation in which the infant's line of sight to the target was blocked as opposed to the experimenter's. Using large barriers, the authors examined 12- and 18-month olds' gaze following in a condition where the experimenter looked toward a target located behind a barrier (experimental condition) and at a visible target located in front of the barrier (control condition), thus drawing attention equally to the barrier in both conditions. The results suggest that infants as young as 12 months will crawl or walk a short distance to look at what the adult is looking at behind a barrier; thus, understanding that there is a connection between a person's eye gaze and the object of her visual attention. Taken together, these findings indicate that infants in their second year of life recognize that a person will see an object if his/her eyes are directed toward the object and if his/her line of sight is not blocked by an obstacle (Flavell, 1992).

Additional evidence for infants' understanding of the referential nature of gaze has also been provided by recent studies using visual habituation methods (Woodward, 2003). Using these experimental methods, research has found that by 8 months of age, infants expect to find an object behind an occluder toward which a person's attentional behaviors (e.g., gaze, head shift) are directed (Csibra & Volein, in press). By 9 months, infants seem able to encode the relation between an actor and the target of her head and eye turns if the turns involve multiple fixations (Johnson, Ok, & Lu, in press).

In contrast to the "richer" interpretation of infants' gaze following, some researchers have offered a "leaner" interpretation (Langton et al., 2000; Moore & Corkum 1994; Moore, 1999; Povinelli, 2001). Specifically, these researchers argue that a person's head turn could draw an infant's attention to a particular location without invoking any understanding of the gazer's attention. For example, an equally likely

explanation for Moll and Tomasello's above mentioned findings (2004) is that the experimenter's looking behavior may have simply attracted the child's attention to a section of space where the target object is located behind the barrier and not because they want to see what the adult is seeing.

One way to demonstrate that infants understand the referential significance of gaze is to examine whether the credibility of a person's looking behavior influences whether or not the child chooses to follow the looker's gaze. Recent research with preschoolers shows that they can appraise the reliability of their informants. 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 (Clement, Koenig & Harris, 2004; Koenig, Clément, & Harris, 2004). Other research has shown that three-year-olds learn new words from confident rather than uncertain speakers (Sabbagh & Baldwin, 2001). To test this idea, infants in the current study were first trained using a variation of Repacholi's search task (1998) in which they either find a toy (Reliable Looker condition) or do not find a toy (Unreliable looker condition) when they followed the experimenter's gaze and excitement as she looked inside a container. This task was originally used to demonstrate that 14- and 18-month-old infants can identify the referent of an adult's emotional display. Then, using a variation of Moll and Tomasello's paradigm (2004), we compared, across these two conditions, infants' gaze following to targets in front and behind a barrier. If infants' gaze following is simply a learned response to a person's global head movement, then infants should follow the experimenter's gaze equally to both target objects in both conditions. However, if infants

understand that the experimenter is directing her attention at a target object, then infants in the reliable looker condition may be more likely to follow the adult's gaze behind the barrier than infants in the unreliable looker condition. In contrast, infants in both conditions should follow the adult's gaze equally to target objects in front of the barrier.

Experiment 1

In this study, we investigated whether 14-month-olds follow the gaze direction of an adult behind various barriers when their gaze and excitement was previously associated with either empty containers or interesting toys within the containers.

Method

Participants

Thirty-eight infants participated in the study; with 20 infants in the reliable looker condition (9 males, 11 females) and 18 in the unreliable looker condition (12 females, 6 males). Children's mean age was 14.33 months (SD = 0.56, range = 13.16 to 15.46 months). Fourteen additional infants were excluded from the study due to fussiness (n = 3), parental interference (n = 4), and lack of compliance with the task (n = 7). On the basis of parental report, all infants had a minimum of a 35-week gestation period and had no vision or hearing impairments. All infants were recruited from birth records provided by a government health services agency. Parents were initially sent a letter describing the purpose of the study and inviting them to participate (see Appendix A for a sample recruitment letter).

Materials

Search task. Three opaque cylindrical plastic containers with loose-fitting lids were used 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 4 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.

Gaze following task. Each infant was exposed to four barriers, which consisted of the following: (1) Blue barrier: solid barrier made of wood (140 cm length, 165 cm height, 45 cm width), (2) Yellow box: a box covered with yellow paper (96 cm length, 64 cm height, 26 cm width), (3) White trolley: wooden movable trolley covered in white Bristol board (95 cm length, 73 cm height, 60 cm width), and (4) Red bucket: plastic bucket (30 cm diameter, 27 cm height).

Four figurines familiar to infants (Tigger, Winnie the Pooh, Baby Bop, and Tinky Winky) were used in the experimental condition, one for each barrier. Four brightly colored stickers (approximately 3 cm length x 4.5 cm height) were used in the control condition. A sticker was placed on the front of each barrier, approximately 20 cm from the bottom.

Design and Procedure

Infants were first brought to a reception room where they were familiarized with the experimenter. During this time, the nature and purpose of the study was explained to the parents and questions were addressed. Parents read and signed consent forms (see Appendix B) and filled out a demographic questionnaire (see Appendix C). Then, parents

were provided instructions regarding their behavior during the testing session (Appendix D). Following a familiarization period, the infant and parent were brought into the testing room where two tasks were administered: a search task and a barrier task. Infants were randomly assigned to two conditions: a reliable looker condition and an unreliable looker condition. All the observations were videotaped.

Search task. A modified version of Repacholi's procedure (1998) was used. This task was designed to train infants to either expect to find a toy after the experimenter looked inside a container with positive affect (reliable looker condition) or to expect to find the container empty (unreliable looker condition). Infants in each group completed two warm-up trials and four training trials. Responses for each of the trials were recorded to indicate whether children (a) opened the lid of the container and (b) examined the contents of the container by either looking inside or by inserting their hand into the container (see Appendix E for a sample coding form).

Each infant was seated in a child seat attached to a table facing the experimenter, and the parent was seated directly behind the child. In the warm-up phase, infants in both the Reliable and Unreliable conditions observed the experimenter looking inside the yellow container while exclaiming, "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 content. The same procedure was repeated with the training trials except orange and blue containers were used. Also, an exclamation ("Wow!") accompanied the experimenter's look inside

the container along with a matching happy facial expression (i.e., raised eyebrows, open mouth in the shape of a smile). In the reliable looker condition, the experimenter looked into a container that had a toy inside. In the unreliable looker condition, the experimenter looked into an empty container. Each demonstration lasted approximately 10 s.

Gaze following task. This procedure closely followed the one designed by Moll and Tomasello (2004) and was used to examine whether infants' gaze following would be influenced by their prior knowledge of the experimenter's credibility in the search task. Consequently, it was always administered after the training task. Three large barriers and a bucket were positioned around a small stool on which the parent was seated with the child. The distance between the stool and the front of each barrier was about 60 cm. For each of the barriers, infants completed a control and an experimental condition before moving onto the next barrier, for a total of 8 trials (4 control, 4 experimental). Overall, order of conditions and order of barriers were counterbalanced across children. For a given child, order of conditions (experimental first or control first) was identical across all four barriers, whereas the side of the barrier on which the experimenter was seated (left side or right side) was counterbalanced across barriers. For each condition, infants' response was coded in terms of whether they followed the experimenter's gaze to the target. Unlike other gaze following experiments with barriers, infants saw no object but a barrier when they turned to look in the direction in which the adult was looking. Consequently, the criterion for gaze following in the experimental condition consisted of the child moving a short distance until he or she had visual access to the back of the barrier. In the case of the bucket, the child had to lean forward and look inside the bucket. Criteria for gaze following in the control condition consisted of

the child moving a short distance to look or point at the sticker in front of the barrier or the bucket (see Appendix F for a sample coding form).

Parents were asked to sit on the stool and to hold their child in front of them until they were given a signal to let their child go. The experimental procedure began with the experimenter kneeling while facing the side of the barrier and attracting the infant's attention by saying, "Hi." When the infant looked toward the experimenter, she began the demonstration. In the experimental condition, the experimenter leaned sideways to look at the figurine behind the barrier, while exclaiming with interest, "Oooooh." Thereafter, the experimenter held her gaze for a duration of 3 s and then moved a step back to allow the infant room to move around the barrier. The distance between the experimenter and the target was approximately 60 cm. If the child did not follow the experimenter's gaze after a 4 s delay, the experimenter repeated the demonstration one more time for a maximum of two trials per condition. The best response was used for data analysis. The same procedure was followed in the control condition, except that the experimenter leaned sideways to look at the sticker in front of the barrier. On trials during which the child did not approach the target, the experimenter did not show them the figurine or sticker so as not to alter their learning experience from the search task. As well, access to the back of the barrier was blocked by the experimenter during the control condition if the child attempted to look or go behind the barrier (in both reliable and unreliable looker conditions). In this way, the infants could not inadvertently discover the toy located behind the barrier, rendering the experimental condition invalid.

Reliability

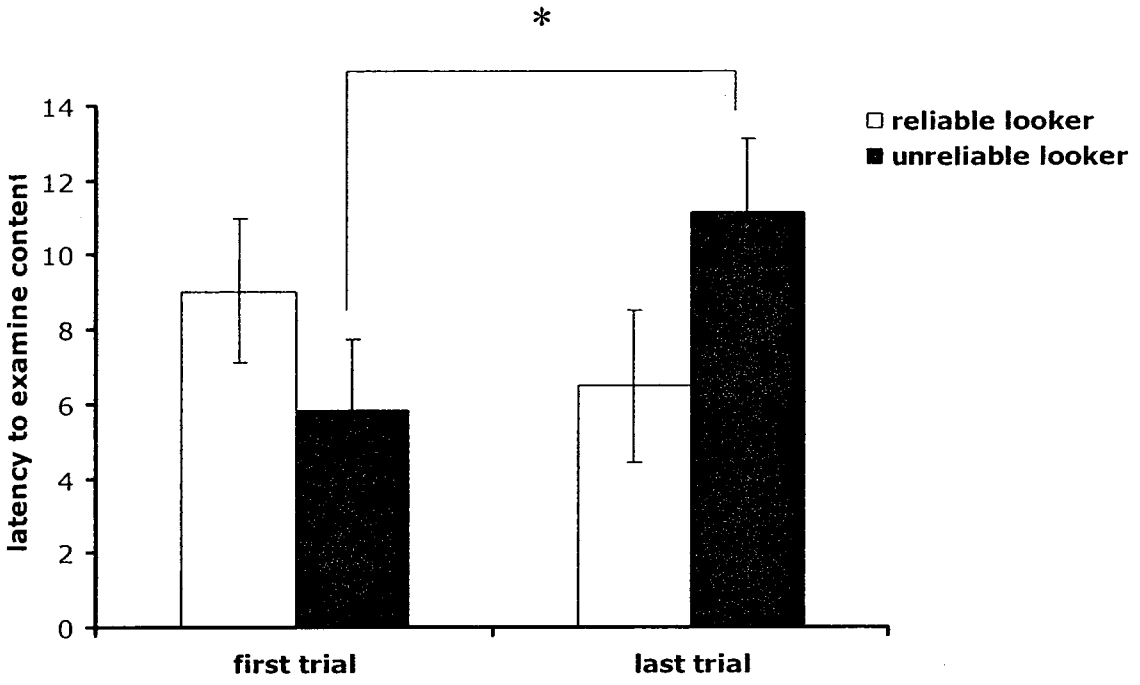
An independent observer coded a random selection of 25% (n = 10) of the videotaped sessions to assess inter-observer reliability, with an equal number of participants selected from each group. Using Pearson product-moment correlations, the mean inter-observer reliability was r = .98 (range = .94 to 1.00) for both the Search and Barrier Tasks.

Results and Discussion

To assess whether the infants from each group paid attention to what the experimenter saw inside the containers during the training task, we compared the number of times infants examined the contents of the container during the training trials (out of 4 trials) in the reliable and unreliable looker conditions. Results indicated that infants in both groups looked equally often inside the containers (reliable looker: M = 3.85, SD = 0.49; unreliable looker: M = 3.83, SD = 0.51), $t(36) = 0.10$, p = .92. Also of interest was whether 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 using an analysis of variance (ANOVA) with Looker Type (Reliable, Unreliable) as the between-subjects factor. As expected, results revealed an interaction between trial and type of looker. Infants in the unreliable looker condition took longer to examine the contents of the container in the last trial (M = 11.14 s, SD = 8.92) as compared to the first training trial (M = 5.84 s, SD = 4.60, $p < .05$), whereas infants in the reliable looker condition took equally long to examine contents in both trials (M = 6.47 s, SD = 7.72, and M = 9.04 s, SD = 10.35 s, respectively, p = .32). This suggests that infants in the unreliable looker condition understood that there was nothing to look at inside the containers and became disinterested in its contents.

Figure 1

Mean latency (max= 30 seconds) to examine contents of container in first and last training trials for reliable and unreliable looker conditions in Experiment 1.



A series of three-way ANOVAs were conducted to examine whether infants' prior experience with the experimenter's reliability during the training task influenced their subsequent gaze following behavior during the gaze following task. First, we conducted a three-way ANOVA with gender and type of looker as between-subjects factors and gaze following condition (control, experimental) as a repeated measure. Since no significant effects were found for gender, a subsequent two-way ANOVA using only type of looker and gaze following condition was conducted. As predicted, a significant interaction between type of looker and gaze following condition was found, $F(1, 36) = 11.65$, $p < .01$. Pairwise comparisons with Bonferonni corrections revealed that infants from the reliable looker condition followed the experimenter's gaze behind the barriers in the experimental trials ($M = 2.20$, $SD = 1.32$) more often than infants in the unreliable looker condition ($M = 0.83$, $SD = .71$, $p < .001$). However, infants in both groups followed the experimenter's gaze equally often in front of the barriers during the control trials (reliable looker: $M = 1.50$, $SD = 1.15$; unreliable looker: $M = 1.78$, $SD = .73$, $p = .32$). Pairwise comparisons also reveal a crossover effect, whereby infants in the reliable Looker group followed the experimenter's gaze more often behind ($M = 2.20$ s, $SD = 1.32$) than in front of the barriers ($M = 1.50$ s, $SD = 1.15$), whereas the opposite pattern was observed with infants in the unreliable looker group (experimental: $M = 0.83$ s, $SD = .71$; control: $M = 1.78$ s, $SD = .73$, respectively), $p < .05$.

To determine whether infants in the reliable Looker condition did not simply learn the demands of the gaze following task better than those in the other group, we examined the proportion of infants who successfully followed the experimenter's gaze to the target behind the barrier in the first trial. Among the infants in the reliable looker group, 70%

of them ($n = 20$) followed the experimenter's gaze to the target behind the barrier, compared to 11% in the Unreliable looker group ($n = 18$), $\chi^2(1, 38) = 13.49, p < .001$. Thus, gaze following experience with additional barriers cannot account for the differences in results between the two groups.

In this experiment, 14-month-olds infants were less likely to follow an adult's gaze to a target location behind a barrier if the looker was unreliable, that is, when she showed happiness while looking inside an empty container in a prior task. Although this finding suggests that infants' behaviors are modulated, as preschoolers, by the reliability of the informant, there is another interpretation for the findings. It could be argued that infants made no attribution of reliability to the experimenter but became bored of following her gaze without finding interesting objects to look at inside the container. In other words, maybe what the training task achieved was simply extinguishing a conditioned response to eye turns. In order to disambiguate these findings, we conducted a second experiment in which a second experimenter administered the gaze following task after the training task with an unreliable looker. We expected that infants would follow gaze behind the screen equally often as the infants who witnessed the reliable looker in Experiment 1 if they are sensitive to an individual's pattern of reliability.

With regard to the crossover pattern observed in the type of looker by gaze following interaction, this pattern of finding seem to support the view that infants are selective in terms of the person's gaze they choose to follow. It appears as though when infants see a target that is clearly visible, they can confirm with their own visual experience what the experimenter is looking at and therefore are more likely to follow the person's gaze. In contrast, when the target is not visible and infants cannot validate what

the other person is seeing, they appear to rely more on their own prior experience with the looker's reliability. Nonetheless, it is important to note that although infants in the reliable looker condition followed gaze more often behind rather than to the front of barriers, it is possible that infants already detected the visible sticker in front of the barrier and therefore did not feel the need to point or move closer to look at it.

Experiment 2

The aim of this study was to determine whether the pattern of results observed in the gaze following task in Experiment 1 was due to an extinction of response acquired during the search task or whether infants can track the reliability of the person's gaze. To further this understanding, the unreliable looker condition of Experiment 1 was replicated, using a different experimenter in the gaze following task to contrast the subjective nature of gaze between an Unreliable and Naïve looker.

Method

Participants

A group of twenty-four infants participated in the study (11 females, 13 males). Infants' mean age was 14.80 months (SD = .57, range = 14.10 to 15.75 months) and were recruited using the same means as in Experiment 1. Fifteen additional infants were excluded from the study on the basis of experimenter error (n = 3), shyness (n = 3), fussiness (n = 4), parental interference (n = 2), not meeting the inclusion criteria (n = 1), and for not examining the contents of the container across the training trials greater than chance (n = 2).

Materials, Design and Procedure

The same materials used in the search and gaze following tasks in Experiment 1 were used in this study. The design of the current experiment replicated that of the unreliable looker condition in the first experiment, whereby infants saw the looker examine the empty containers and express happiness in the search task. However, a different experimenter (naïve looker) was used in the gaze following task to determine whether infants understand the subjectivity of a person's gaze. Therefore, infants did not receive prior training regarding the "reliability" of the Naïve Looker's gaze. Infants' responses in the search and gaze following tasks were scored in the same way as in Experiment 1.

Reliability

An independent observer coded a random selection of 25% (n = 6) of the videotaped sessions to assess inter-observer reliability. Using Pearson product-moment correlations, the mean inter-observer reliability was r = .97 (range = .82 to 1.00) for both the Search and Barrier Tasks.

Results and Discussion

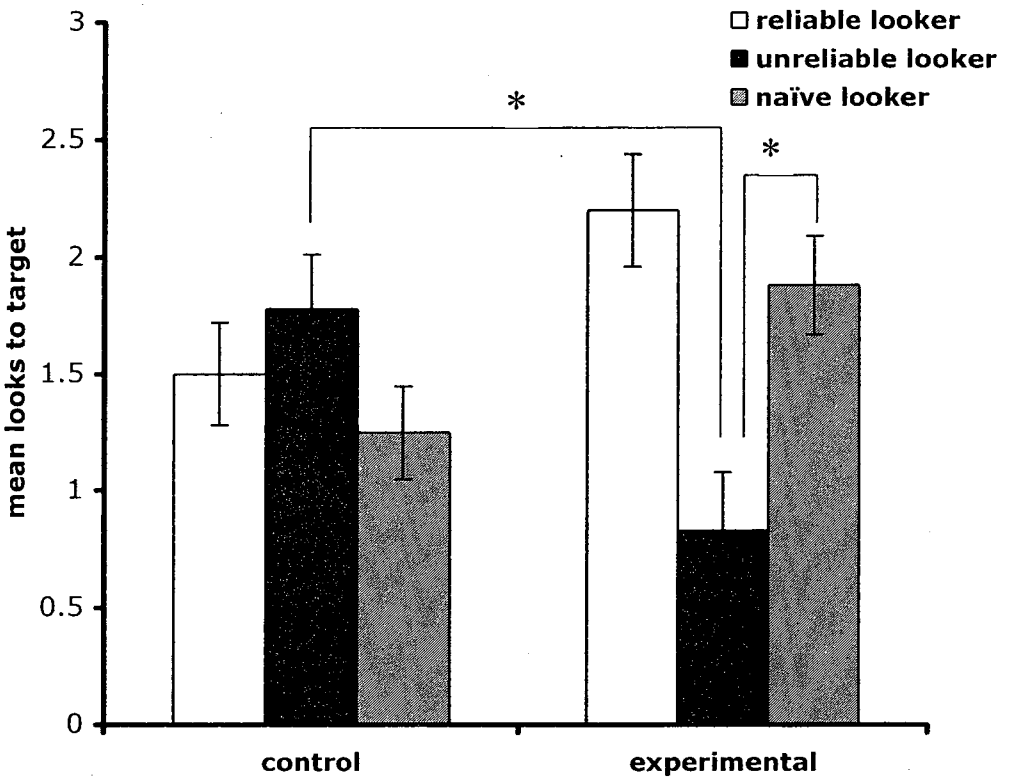
To ensure that infants paid attention to what the experimenter saw in the containers during the search task, we compared the number of times infants examined the contents of the container during the training trials (out of 4 trials) in this study to infants in the Reliable and unreliable looker conditions in Experiment 1. Pairwise comparisons with Bonferroni corrections indicated that infants looked equally often inside the containers (M = 3.69, SD = 0.60) as compared to infants in the reliable (M = 3.85 s, SD = 0.49) and unreliable looker conditions (M = 3.83, SD = 0.51), $F(2, 53) = 0.48$, p = .62. To

determine whether infants developed an expectation about the content of the containers over time, we compared the latency to examine the content of the containers between the first and last trial of the training phase. As expected, results revealed that infants took longer to examine the contents of the container in the first trial (M = 6.90 s, SD = 8.31) as compared to the last training trial (M = 13.95 s, SD = 11.66), $t(23) = 2.83$, $p < .01$.

To examine whether infants could track the reliability of the experimenter's visual perception, we conducted a 2 x 2 x 3 ANOVA with gender and type of looker (reliable, unreliable, naïve) as between-subjects factors and gaze following condition (experimental, control) as a repeated measure. Since no significant effects for gender were found, a subsequent two-way ANOVA using only type of looker and gaze following condition was conducted. Figure 2 presents the mean scores (out of 4) for looking in front of and behind barriers in the three looker conditions across the two experiments. As predicted, a significant interaction between type of looker and gaze following condition, $F(2, 59) = 8.31$, $p < .001$, revealed that infants in the "Naive" Looker condition followed the experimenter's gaze behind the barriers in the experimental trials (M = 2.20, SD = 1.32) more often than infants in the unreliable looker condition (M = 0.83, SD = .71), $p <$ .01, though infants in both groups followed the experimenter's gaze equally often in front of the barriers during the control trials (naïve looker: M = 1.25, SD = .99; unreliable looker: M = 1.78, SD = .73), p = .27. Also, as expected, pairwise comparisons revealed that infants in the Naïve Looker condition followed the experimenter's gaze behind the barrier equally often as infants who experienced the reliable looker (naïve looker: M = 1.88, SD = .95; reliable looker: M = 2.20, SD = 1.32), p = .91. Likewise, no significant differences were observed between the number of times infants followed the

Figure 2

Mean scores (out of 4) for looking at targets in the control and experimental conditions in the Reliable, Unreliable, and Naïve Looker conditions. Error bars show standard errors of the means.



experimenter's gaze in the control condition in the naïve and reliable looker conditions (naïve looker: $M = 1.25$, $SD = .99$; reliable looker: $M = 1.50$, $SD = 1.15$), $p = .27$.

To determine whether infants in the naïve looker condition understood the demands of the gaze following task and did not simply follow the experimenter's gaze as a result of experience with subsequent barriers, we compared the proportion of infants who successfully followed the experimenter's gaze to the target behind the barrier in the first trial with infants in the reliable looker condition in Experiment 1. Among the infants in the naïve looker group, 42% of infants ($n = 10$) followed the experimenter's gaze to the target behind the barrier. This proportion of infants is significantly higher than that of the unreliable looker group (11%, $n = 18$) in Experiment 1, $\chi^2 = 4.71$, $p < .05$, whereas there were no such differences with the reliable looker group (70%, $n = 20$), $\chi^2 = 1.46$, $p > .05$. This suggests that learning experience cannot account for infants' gaze following behavior in the experimental condition.

General Discussion

In this paper, we considered infants' abilities to attribute visual experiences to individuals. Infants observed an adult look at a target in front and behind a barrier. In Experiment 1, 14-month-old infants who had previously observed an adult react positively to a box that contained a toy were more likely to follow her gaze to a target hidden behind a barrier compared to infants who had previously seen the adult act similarly toward an empty container as if it contained a toy. Overall, infants in both groups had no difficulty following the experimenter's gaze to the target in front of the barrier, suggesting that the differential gaze following behavior was not a general avoidance of the unreliable looker's gaze. These findings replicate the results reported by

Moll and Tomasello (2004) by demonstrating that infants are able to follow an adult's gaze to a space outside their field of vision (behind a barrier). Our study extends these findings by showing that infants' gaze following is influenced by their previous experience with the looker. In Experiment 2, infants had experience with an unreliable looker in the search task but were requested to follow the gaze of a second, naïve looker behind and in front of barriers. In contrast to the situation where the unreliable looker administered both tasks, infants followed gaze behind barriers equally often as the infants who had experienced a reliable looker. These findings ruled out an interpretation of the data of Experiment 1 as being due to a simple decline of interest in following the gaze of the unreliable looker in the absence of an interesting object to look at. This is the first study to date to show that infants are sensitive to a person's record of reliability. Thus far, the influence of prior experience with individuals on children's behavior has only been demonstrated in preschoolers (Jaswal & Neely, 2006; Koenig, Clement, & Harris, 2004; Koenig & Harris, 2005).

In our view, prior exposure to what an adult sees provides a unique way of examining whether infants understand the referential nature of gaze. If infants simply followed an adult's head turn as a result of an automatic gaze mechanism (e.g., Langton, Watt, & Bruce, 2000) or a learned contingency (Moore, 1996), then infants from both the Reliable and Unreliable looker groups should have followed the adult's head turn to the target behind the barrier. However, the differential response between the two groups in the experimental condition of the gaze following task suggests that infants in the Unreliable looker group were inferring something different from infants in the Reliable looker group. We propose that this differential response is attributed to infants'

understanding of another person's gaze as both referential and experiential. A full-fledged understanding of vision requires that one understands vision as intentionally directed at an object, and thus referring to the object (the referential component). However, it also involves an understanding that the visual connection between the looker and the object leads to a visual experience that is distinctive. An experiential understanding of vision has been demonstrated in studies on Level-1 visual perspective taking with 2- to 4- year-old children (Flavell, Shipstead, & Croft, 1978; Masangkay, 1974; Wellman, Phillips, & Rodriguez, 2000). Recent studies employing looking-time methods have revealed that infants as young as 12.5 months might understand that another person does not have visual access to an object that they themselves are able to see (Luo & Baillargeon, in press; Sodian, Thoermer, & Metz, 2007). The present findings, particularly those based on the switch-actor procedure, provide additional support for the hypothesis that infants have nascent understanding of the experience of seeing.

The current studies add to the growing number of studies that show that early in the second year, infants reach important milestones in their understanding of vision. Previous research with occluders has shown that infants know that another person cannot see something they can see. At the same time, when an object is hidden behind a barrier, research has shown that infants know that another person can see something they cannot see. Our demonstration that infants associate different visual experiences with individual agents provide one of the strongest pieces of evidence to date that infants understand that others see things. Of course, infants' understanding of the epistemic aspects of seeing become more elaborate in the following months and years, as other aspects of folk

psychology develop (Doherty, 2006). For example, it is not until the age of 18 months that infants can encode not only what another person sees and does not see, but also can infer subsequent correct or incorrect action from a person's access to information (Poulin-Dubois, Demke, & Olineck, 2007; Poulin-Dubois, Sodian, Metz, Tilden, & Schoeppner, in press). Between 18 and 24 months of age, children develop a robust reliance on gaze cues in word learning situations (Baldwin, 1991, 1993; Baldwin et al, 1996; Hollich, Hirsh-Pasek, & Golinkoff, 2000; Moore, Angelopoulos, & Bennett, 1999; Akhtar, 2005; Sabbagh & Baldwin, 2005; Graham , Nilsen & Nayer, 2007). There is also evidence that explicit judgment of eye-direction is a skill that improves between 3 and 4 years of age (Baron-Cohen & Cross, 1992; Doherty & Anderson, 1999, Doherty, 2006). Another level of eye gaze comprehension involves the realization that direction of eye gaze can indicate mental states (Povinelli & Eddy, 1996). By preschool age, children can use eye gaze to infer the object of desire (Baron-Cohen et al 1995, Lee, Eskritt, Symons, & Muir, 1998), knowledge (Pillow, 1989; Wimmer, Hogrefe, & Perner, 1988), and thinking (Flavell, Green, Flavell, 1995). Finally, the most sophisticated forms of understanding of eye gaze information are reached at 6 or 7 years of age (see Eskritt & Lee, 2007 for a review).

The current findings raise a number of questions for future investigations. These include the youngest age at which children could understand the subjective nature of gaze, as tested with the present paradigm. Since previous research has shown that Level 1 perspective taking can be observed in infants as young as 12 months, further research is needed to determine whether infants younger than those tested in the present set of studies understand what different individuals can and cannot see. Another important issue

concerns the extent to which infants generalize their knowledge about the reliability of a person' gaze to contexts that are more remote from the one tested in the current tasks. Experiments are under way in our laboratory to examine the possibility that 16-month-old infants exposed to an unreliable looker in a search task will fail an implicit version of the false belief task involving the same actor (Onishi & Baillargeon, 2005). Our intuition is that such generalized transfer will only develop after the age of 18 months, as it requires infants to develop a stable trait of the person. These questions aside, our findings have revealed that early in the second year, infants attribute a subjective sense of vision to others.

Chapter 3

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

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

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 four 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). Based on this view, infants before the age of four 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 does not only entail 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 requires that the child be capable of responding correctly while putting aside his or her knowledge about the toy's actual hidden location and to 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, & Cisbra, 2007).

Recent research on early-developing ToM mechanisms has revealed that infants in the middle of their second 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 her prior visual experience, or lack thereof. Using the violation of expectancy paradigm and a forced-choice procedure based on the preferential looking paradigm, infants were exposed 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 for the location of the object while the other still frame reflected her ignorance. The authors expected that if infants understand that the actor had a visual experience that directly influences her behavior, they 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. Their 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 subsequent behavior. By 24 months of age, the infants inferred a person's search behavior as a function of their 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 second 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 toy's hidden 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, 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, infants watched as the agent reached for the object in the correct location (Box B) or in the incorrect location (Box A). Interestingly, 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 infants expected the agent to search in the location 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, Senju, and Csibra (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 infants' anticipatory looking behavior while they watched actions on a computer monitor. Consistent with Onishi and Baillargeon's findings (2005), 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 toy's true hidden 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 three 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, they tested whether 13-month-olds expect agents to behave in a way that is consistent with the information to which they have been exposed. Results revealed that 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 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 their 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 processing a new association because they are examining a new combination of the elements as compared to a previous association, in which the combination of elements are 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 three-year-olds learn new words from confident rather than uncertain speakers (Sabbagh & Baldwin, 2001). Recently, this line of research has been 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, 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 look at a target object that was visible to the child in front of a barrier (control condition) and to a target object behind a barrier (experimental condition) that was concealed from the child but visible to the actor. Following each condition, infants' gaze following was measured by examining whether 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 as compared to infants in the unreliable looker condition. In contrast, when the target was visible to the child, infants in both looker groups followed the gaze of the looker to the target equally often. To confirm that infants in the unreliable looker group were avoiding the agent due to selective mistrust, a switch-actor design was used in a follow-up study. In fact, when infants were trained with an unreliable looker in the search task and then tested with an unfamiliar looker in the barrier task, infants treated the new looker as though she was reliable by following her gaze to the front and behind the barrier equally often as infants in the reliable looker condition in the first experiment. In contrast, infants followed the unfamiliar looker's gaze behind the barrier more often than infants 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. It would be therefore interesting to explore whether the reliability of the looker will have an effect on infants' attribution of beliefs based on visual experience (seeing=knowing).

This study aimed to examine 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, infants were first trained to develop trust or mistrust of a person. Following the Chow et al. (2008) procedure, infants either found (reliable looker condition) or did not find a toy (unreliable looker condition) inside a container after witnessing an experimenter show excitement while gazing at its content. Following the reliability training, 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 in attributing beliefs to that experimenter. The reason for this may lie with infants' prior exposure to misleading attentional cues by that experimenter who looked excitedly into an empty box. Consequently, infants would experience difficulties in making a connection between her visual attention, while the toy was being hidden, and her subsequent search behaviour. 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, it was expected that only 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 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

A total of 49 16-month-olds infants participated in the study. Twenty-two infants were assigned to the reliable looker group (10 males and 12 females; $M = 16.27$ months, range = 15.03 to 17.46 months) and 27 infants were assigned to the unreliable looker group (20 males, 7 females; $M = 16.45$ months, range = 15.49 to 19.13 months). The age 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 due to 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 infants who only looked at the experimenter but at neither 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. All infants were recruited from birth records provided by a government health services agency (see Appendix G and H for sample recruitment letter and consent form respectively).

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 4 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 theatre, which was approximately 90 cm away. A red cup covered by colourful stickers rested on the stage 18 cm between two boxes (14 cm

width, 14cm length, 14cm height): one yellow and one green. 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 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 theatre and was focused on the infant's face. The recordings were later used to code the direction of infants' gaze during each trial. In addition, 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 inbetween each trial, the contents of the stage were concealed by blinds, which were operated by the experimenter.

Design and Procedure

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 infants first completed the search task followed by the true belief task. Infants were randomly assigned to one of two conditions: a reliable looker condition or an unreliable looker condition. All the observations were videotaped.

Search task. A modified version of Repacholi's procedure (1998) 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, infants found a toy in a container after observing the experimenter look inside it while showing positive affect. In the unreliable looker condition, infants observed the same demonstration but found the container empty. Infants in each group completed two warm-up trials and four training trials. Responses for each of the trials were recorded to indicate whether infants (a) 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 (see Appendix E for sample coding sheet).

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, 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 content. 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 behaviour on the basis of her true or false belief about a toy's hidden location. Using a violation-of-expectation paradigm, all infants completed three familiarization trials, one belief induction trial, and one test trial. The infant was seated facing the puppet theatre 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 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 two consecutive seconds after having looked at it for a minimum of two cumulative seconds. The blinds were lowered in 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, 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 towards the new object location.

Next, the infants received a test trial during which the experimenter reached into one of the two boxes during the pretrial. 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 in were counterbalanced across looker conditions. Infants' total looking time at the display following the pretrial was coded from videotape after the session by the experimenter. The total looking time at the display consisted of infants' looking time at the two boxes and at the experimenter (see Appendix I for sample coding sheet).

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 inter-observer reliability, with an equal number of participants selected from each group. A portion of the random selection (n = 4) included participants whose looking time at the congruent and incongruent search locations in the true belief task were zero to determine the accuracy of the coding. Using Pearson product-moment correlations, the mean inter-observer reliability for examination of containers and latency of examination for the search task was r = .98 (range = .86 to 1.00). The mean inter-observer reliability for the looking time at the congruent and incongruent search locations was r = .99, whereas the mean inter-observer reliability for the looking time at the experimenter during the test

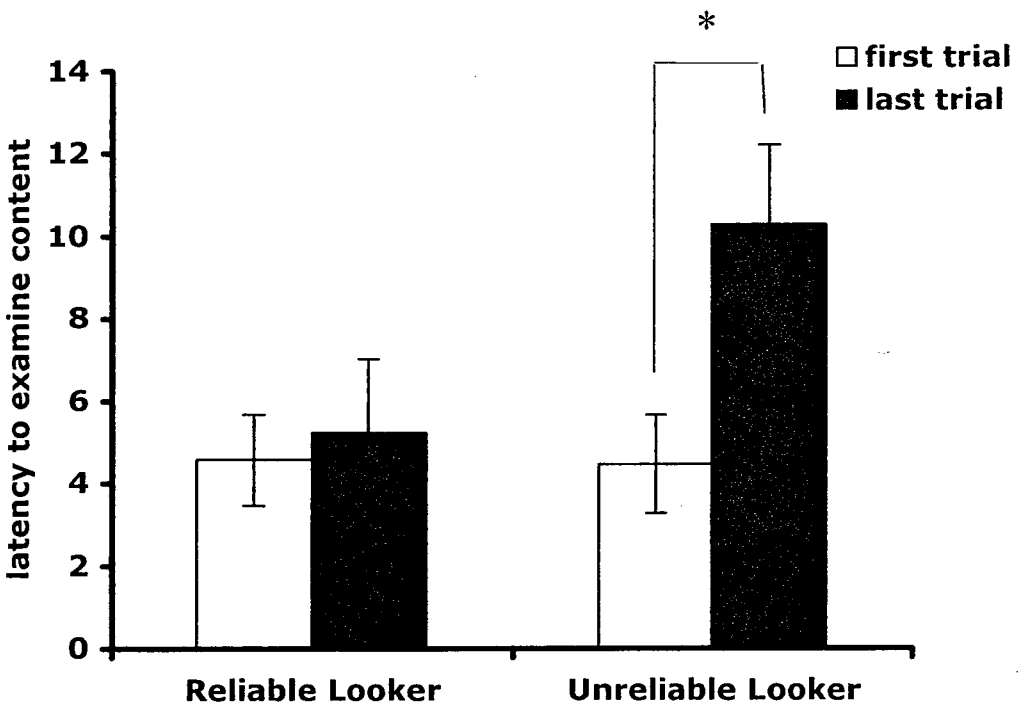
trial was $r = .97$. Finally, the mean inter-observer reliability for the overall looking time at the display during the test trial was $r = .99$ (range = .97 to 1.00).

Results

In order to assess whether the infants from each group paid attention to the content of the containers during the training task, we compared the number of times 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. Results indicated that 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 infants developed an expectation about the content of the containers over time. Figure 3 shows infants' latency to examine the content of containers between the first and last trial of the training phase using 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 infants who were misled by the experimenter in the search task (unreliable looker condition) to become gradually disinterested in the content of the box. As expected, results revealed a significant interaction between trial and looker type, $F(1, 47) = 4.19$, $p < .05$, $\eta^2_p = .08$. Pairwise comparisons with Bonferonni adjustments revealed that infants in the unreliable looker condition took longer before examining the contents of the container in the last trial ($M = 11.17$ s, $SD = 10.75$) as compared to the first training trial ($M = 5.13$ s, $SD = 5.29$, $p < .001$), whereas 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, $SD =$

Figure 3

Mean latency (max = 30 seconds) 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.



6.46 s, $p = .75$). This suggests that infants in the unreliable looker condition learned that there was nothing to look at inside the containers over trials and became disinterested in its contents after looking into an empty container repeatedly.

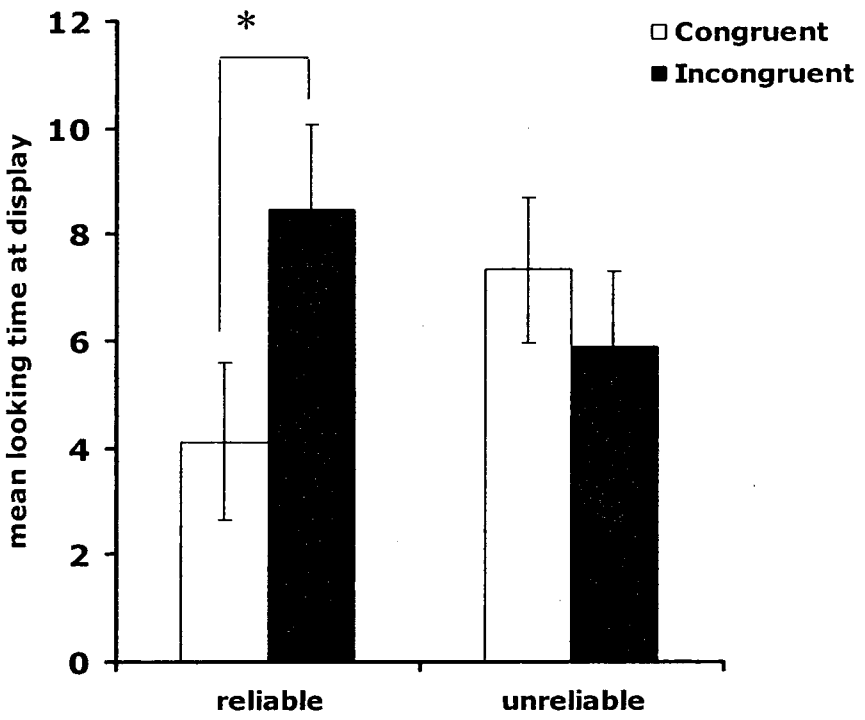
A series of three-way ANOVAs were conducted to examine whether infants' prior experience with the experimenter's looking reliability during the training task influenced their subsequent reaction to the looker's search behavior in the true belief task. First, infants' overall looking time at the event 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. Since 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, $F(1, 45) = 3.89, p < .05, \eta^2_p = .08$ (see Figure 4). Pairwise comparisons with Bonferonni corrections revealed that 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 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 behaviour in a belief attribution task.

To rule out the possibility that infants in the unreliable looker group may have been inattentive to the experimenter's demonstrations during the familiarization trials due to 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.

Results revealed that 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, $SD = 6.00$), $t(47) = .19$, $p = .85$. Similar results were also found when

Figure 4

Mean looking time (max = 30 seconds) at display in congruent and incongruent test conditions for reliable and unreliable looker groups. Error bars show standard error of the means.



comparing 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, $SD = 6.83$), $t(47) = .31$, $p = .76$, $d = .09$, and when comparing 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, $SD = 3.14$), $t(47) = .46$, $p = .65$, $d = .13$. In addition, we expected 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 by looker type interaction, $F(1, 47) = 4.25$, $p < .05$. Pairwise comparisons with Bonferonni corrections revealed that 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, $SD = 1.04$, $p < .001$). Overall, these findings suggest that 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 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 reported evidence that 16-month-old infants respond differently to reliable and unreliable lookers and use their experience with them to subsequently

judge their behaviors in a belief attribution task. 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 mislead by the unreliable looker became gradually less motivated to verify the content of the container, as evidenced by their increased latency to open the lid. This significant increase in latency over time provides evidence that infants had developed mistrust toward the referential behaviors of the unreliable looker by the end of the training phase. Infants then watched the same experimenter act as the agent in a nonverbal true belief test (Onishi & Baillargeon, 2005). In this task, 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, infants looked longer during the trials where 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, 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 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 infants in the unreliable looker condition had become frustrated by the end of the search task as they kept having their expectations about the content 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 infants' looking times during that critical trial revealed that infants from both groups were equally attentive during that trial. Other evidence that infants were attentive to the actions of the agents regardless of her reliability record was the looking time pattern at the experimenter's hand during the test trials. In both groups, 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 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 importantly, the current 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, Senju, & Csibra, 2007; Surian, Caldi, & Sperber, 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 on-line prediction that the agent should look for the object at the last place they saw the object? In other words, if the rule-based explanation applied, then infants in the unreliable looker group would be demonstrating the same looking time pattern during the test trial as infants in the reliable looker. Furthermore, 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 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 proven to be inaccurate in the past would prove to be 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 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 (Meltzoff, 1988; Gergely, Bekkering, & Király, 2002). 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 current study adds to the growing number of studies that show that early in the second 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 second 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.

Chapter 4

General Discussion

There have been numerous studies that have examined infants' understanding of other people's perception and beliefs, from examining the cues that elicit gaze (Brooks & Meltzoff, 2002, 2005; Caron, Kiel, Dayton, & Butler, 2002; Dunphy-Lelii & Wellman, 2004; Moll & Tomasello, 2004; Sodian et al., 2007) to testing infants' expectations regarding where an actor should search for a hidden object on the basis of her true or false belief (Onishi & Baillargeon, 2005; Surian, Caldi, & Sperber, 2007). However, there remains considerable disagreement in the literature as to how "richly" to interpret infants' gaze following and looking time behaviors on theory of mind tasks (e.g., Moll & Tomasello, 2004; Onishi & Baillargeon, 2005).

According to the rich interpretation of gaze following, children as early as 12 months are credited for some understanding about the visual experience of others. For example, when infants follow a person's gaze to a target located behind a barrier, their action is interpreted as their desire to "see what the adult sees." As such, infants are argued to have an implicit understanding of "seeing" (Carpenter, Nagell, & Tomasello, 1998; Dunphy-Lelii & Wellman, 2004). Recently, infants' ability to represent another person's visual perception was more clearly demonstrated in a recent study that examined Level-1 perspective taking (Moll & Tomasello, 2006). When an adult asked 24- and 18-month-olds for help searching for a toy, only the 24-month-olds correctly gave the adult the toy she was searching for by handing to her the object that was occluded from her view (although not occluded from the child's view) and not the object that was visible to both of them. As such, infants' correct behavioral choice was interpreted as an

understanding of what another person could and could not see when that differed from what they saw.

Likewise, for belief understanding, those in favor of the rich interpretation have argued that children as young as 15 months of age have insight into whether a person acts on the basis of a correct (true belief) or mistaken view (false belief) (Onishi & Baillargeon, 2005; Southgate, Senju, & Csibra, 2007; Surian, Calder, & Sperber, 2007). Conversely, those in favor of a leaner, less mentalistic explanation of infants' actions have argued that it is not until the age of 4 that children undergo a real change in their conceptual understanding of other people's minds, acquiring a previous absent representational concept of belief (Flavell, 1999, Perner, 1993, Wellman, Cross, & Watson, 2001), which allows them to succeed on verbal false belief tasks. Likewise, infants' ability to follow gaze and predict how a person will act merely shows that infants represent various regularities in people's overt behaviours (e.g., following a head turn as a predictive cue, looking where a person last searched for an object) and does not reflect an understanding of the mind mediating the behavior.

The main purpose of the present dissertation was to shed light on the debate between rich versus lean interpretations of infants' actions by investigating whether the prior reliability of a person's gaze influences infants' implicit understanding of other people's visual perception and beliefs. To this end, the three studies conducted examined whether young infants take into account their prior experience with the reliability of a person's gaze to decide whether or not to follow the person's gaze to a non-visible target and to attribute beliefs.

The first paper (Chow, Poulin-Dubois, & Lewis, 2008) examined whether 14-

month-olds understand the subjective nature of gaze by examining whether their gaze following pattern differed depending on the reliability of the looker. In this way, we could clarify whether infants' pattern of gaze following is due to an implicit understanding that a person's gaze is directed at an object and is, therefore, referential in nature or whether their gaze following is due to a learned association between a person's eyes and something interesting to look at, as implied in the extant literature. In this series of studies, infants were first trained on a search task to expect a person's gaze to be either reliable or unreliable and then completed a gaze following task in which their gaze following was measured following a demonstration either by the same adult (either reliable or unreliable) or a different adult (novel) looking at a target visible in front of a barrier (control condition) or hidden from the infants' view behind (experimental condition) the barrier. As expected, infants in the reliable looker group were more likely to follow the same experimenter's gaze to the hidden target as compared to those infants in the unreliable looker group. In contrast, there were no differences observed in infants' gaze following for both looker groups with respect to the control condition, suggesting that infants are able to track the reliability of the looker across tasks when deciding whether or not to follow her gaze. An important finding reported in this paper (Experiment 1) was that infants' gaze following pattern in the unreliable looker group in the gaze following task could not be attributed to conditioned avoidance of the experimenter who repeatedly violated their trust during the search task. Infants' responses in the control condition addresses this point, as their gaze following patterns did not differ across the two looker groups. If infants in the unreliable looker group were simply avoiding the experimenter due to conditioned avoidance, we would expect the infants to

also refrain from following her gaze to the visible target in front of the barrier as compared to those in the reliable looker group. Furthermore, when a novel person was introduced, using a switch-actor design, in the gaze following task (Experiment 2) after infants had been trained with a person whose gaze was unreliable in the search task, they followed the novel person's gaze to the target behind the barrier more often than infants in the unreliable looker group; whereas no difference in gaze following was observed between the two groups when the target was visible. Taken together, these findings suggest that not only do infants keep track of a person's record of reliability across contexts but also across individuals, such that when they encounter a person who has not violated their trust regarding the reliability of their gaze, they treat her as reliable by default. Findings from the gaze following studies provide additional evidence that young infants have some implicit understanding of what others see and also strengthen the argument for a richer interpretation of infants' gaze following. In particular, infants do not indiscriminately follow gaze due to a learned behavior or a reflexive response but follow a person's gaze on the basis of their reliability status; thus ruling out lower-level strategies in accounting for infants' gaze following pattern.

Overall, the findings from the first paper contribute to the growing research on the developmental course of understanding visual perception in infancy. It seems that infants progress from showing a sensitivity and preference for looking at eyes over other facial features at 3 months of age (Maurer & Salapatek, 1976) to following gaze direction in the middle of the first year (e.g., D'Entremont, Hains, & Muir, 1997), and later taking into account barriers when deciding to follow a person's gaze (Moll & Tomasello, 2004). Then, infants at 14 months of age consider the reliability of a person's gaze when

attributing visual perception in a gaze following task. This rudimentary form of perspective taking further develops for several months, culminating with 24-month-olds showing a clearer pattern of Level-1 perspective-taking when they offer an object to the adult that is visible from their perspective (but not from the adult's perspective) rather than the object in plain sight.

The second paper (Poulin-Dubois & Chow, 2009) addressed whether 16-month-olds' ability to predict a person's search for a hidden toy depends on the eye gaze of that person. Also, we were interested in whether infants can generalize their knowledge regarding the reliability of the looker to a very different context (e.g., another theory of mind task) to determine the scope of their trust. Again, infants were first trained on the search task before their looking time was measured on the true belief task. After being familiarized with the adult hiding an object in one of two boxes and subsequently searching for it, infants then observed as the adult witnessed the transfer of the object's location from one box to another during the induction trial. In the test trial, infants then observed as the adult searched for the object in the correct or incorrect location. As expected, those infants who had been trained with a reliable looker on the search task were surprised and therefore looked longer when the same actor searched in the incorrect location for a toy as compared to the correct location. This finding is consistent with previous findings showing true belief understanding in 15-month-olds (Onishi & Baillargeon, 2005). More interestingly, those infants who had been trained by an unreliable looker on the search task looked equally long when the actor searched in the correct and incorrect locations for the toy, suggesting that infants may have inferred that because her gaze was previously unreliable, it may be equally uninformative in the true

belief task. As such, infants may have suspended any prediction regarding where the actor should search, since her search behavior was not contingent upon the information provided by her eyes. Taken together, findings from this study are the first to show that 16-month-olds are able to differentially attribute beliefs depending on the person's past record of reliability. In addition, they are able to hold the information regarding a person's prior record of reliability in mind and generalize this knowledge from a search task, which involves gaze following behavior, to a theory of mind task that examines infants' understanding of true beliefs.

The present research provides several significant contributions to the area of mental state understanding in infancy. First, it was previously believed that only 4-year-olds understood a critical aspect of the mind, such as beliefs, based on the well-documented failure of young children on the classic verbal belief tasks (Baron-Cohen, Leslie, & Frith, 1985; Wellman & Bartsch, 1988; Wimmer & Perner, 1983). However, findings from the current true belief study replicate and extend findings from studies examining infants' implicit understanding of beliefs (Onishi & Baillargeon, 2005) and challenge the late ontogeny of belief understanding. Although young infants certainly lack the more sophisticated understanding of the mind that adults or older children have, it appears that even they have some insight into the nature of beliefs. If so, the question arises why 4-year-olds would fail to provide the correct answer in a classic false belief task when 16-month-olds, in the current study, can differentially attribute beliefs based on the person's past record of reliability. Part of the answer may lie with the greater executive demands that are required with judgments about false beliefs relative to nonverbal tasks, such as those that rely on looking time measures. It is possible that

looking time studies tap into infant cognitive competencies in a different way than more active measures in which infants must inhibit an incorrect but compelling answer and make an active choice based on what they experience in the experiment (Moll, Carpenter, & Tomasello, 2007).

The second significant contribution the current research provides is an attempt to clarify the depth of infants' understanding of other people's mental states. As mentioned earlier, interpretations of infants' gaze following and looking times on non-verbal false belief tasks have been the subject of much debate. Do the available findings indicate that infants represent people as having inner mental states, such as perceptions and beliefs, or are there more parsimonious explanations that subserve their behaviour, such as following learned rules about behavior (Moore & Corkum, 1994; Corkum & Moore, 1995; Moore, 2006; Perner & Ruffman, 2005)? Therefore, to shed light on this debate, evidence would need to be garnered to empirically validate nonverbal tasks to ensure that they measure the constructs (visual perception and beliefs) they are intended to measure. Certainly, the non-verbal tasks, such as the gaze following task and the true belief task, have been used extensively in other research investigating infants' understanding of mental states, such as visual perception, beliefs, goals and intentions (Moll & Tomasello, 2004; Gergely, Nádasdy, Csibra, Biró, 1995; Onishi & Baillargeon, 2005). Nonetheless, assessing infants' knowledge from simple measures remains notoriously difficult due to the ambiguities in infants' limited repertoire of behaviors (Munakata, 2000). For example, to assess infants' attribution of beliefs in the true belief task, a violation of expectation method was used. The premise of this method is based on infants' propensity to look longer at events that violate their expectations than at events that are familiar. As

such, an increase in infants' looking time at an event is interpreted as a distinction between one event over another. Whether an increase in looking time is interpreted as evidence for conceptual understanding or not is a challenge that has sparked stimulating debates about what infants know about other people's mental states. Regardless of whether this is interpreted as evidence for the conceptual understanding of true belief, what the present research does reveal is that infants know what others have and have not witnessed in the immediate past and can adapt their behavior (e.g., expectations) according to that knowledge.

The last important contribution this research provides is to the field of trust understanding by demonstrating that even young infants are sensitive to a person's record of reliability and can use this information beyond just the domain of word-learning, object-labeling, and functional use of a common object (Birch, Vauthier, & Bloom, 2008; Clement, Koenig, & Harris, 2004; Koenig, Clement, & Harris, 2004). Given children's emotional dependence on other people and their reliance on adults' testimony to learn about the world, it is important to determine whether they have a wide-ranging acceptance of adult testimony and the heuristics they use for evaluating what they are told or shown. Although, there is ample evidence that preschoolers are able to demonstrate selective trust when learning new information, the current research is the first to address whether infants also monitor adults' behavior for their veracity and how that may influence their judgments about another person's mental state. Based on the findings from the current research, we conjecture that 14- and 16-month-old infants can establish a cognitive profile of their informants whereby they form a global impression of the adult as being either epistemically trustworthy or untrustworthy, using information from the

informant's past reliability to create a profile.

Limitations and Future Directions

A differential pattern of gaze following and belief attribution was observed that demonstrate infants' sensitivity to a person's record of reliability when attributing perception and beliefs. However, one might argue that infants in the true belief task did not have an opportunity to directly contrast the belief of the reliable and unreliable looker given that the experimenter in the training and true belief tasks are the same. This represents a limitation of the between-subject design that we used in the true belief task. Recall that a follow-up study was conducted in the second experiment of the first paper in which we used a switch-actor design to determine whether infants would generalize their understanding of what an unreliable looker will see from the training on the search task to a naïve looker, who has never violated their expectation about gaze, in the gaze following task. In this way, we were able to assess whether infants' pattern of gaze following was due to a conditioned avoidance of the adult or due to selective trust, which represents a more stringent control. Therefore, future studies should include a similar switch-actor design as a control measure to evaluate infants' belief understanding. Nonetheless, several follow-up analyses in the true belief study (Experiment 3) addresses whether infants' belief attribution in the unreliable looker condition was due to a conditioned avoidance or due to selective trust. Comparing the looking times between infants in the reliable and unreliable looker groups when the adult witnessed the transfer of the object's location during the induction trial and their looking time when the actor searched for the hidden toy during the test trial did not reveal significant differences between the two groups. In the absence of the switch-actor design, this pattern of findings provides

evidence that infants' behavior during the true belief task could not be explained by lack of attention to the unreliable adult's actions or due to avoidance.

Another limitation of the current dissertation is that only two theory of mind tasks were used to examine the extent to which infants' knowledge about a person's past visual reliability influenced their judgment. As a result, it would be beneficial for future research to explore the scope of infants' selective trust. For example, will infants generalize their knowledge about a person's past reliability to other theory of mind tasks that examine infants' understanding of intentions and desires? Futhermore, it would be interesting to explore whether the reliability of an individual's gaze influence infants' observational learning, such as their decision to imitate novel actions modeled by the same individual. Previous studies have shown that 14-month-olds imitate a novel behavior modeled by an actor (Gergely, Bekkering, & Kiràly, 2002; Meltzoff, 1988). That is, when a group of 14-month-olds watched an actor activate a light-box by leaning forward and touching its top with her forehead, infants were more likely to re-enact the same behavior to achieve the outcome. In contrast, infants in the control group, who witnessed the same demonstration with an actor whose hands were concealed, were more likely to activate the light-box using their hands. These findings were taken as evidence that infants can imitate a goal-directed action when they consider the means by which the light-box is activated (using forehead or using hands) to be the most rational alternative. As a result, one would expect that infants who are trained with an unreliable looker would be less likely to imitate the novel action with their forehead as compared to those who are trained with a reliable looker. Therefore, if infants can track a person's history of being accurate or inaccurate in their visual perception and generalize it across a variety of

domains (e.g., word learning, social referencing, theory of mind tasks), researchers can then develop a better understanding of whether infants attribute reliability as a stable, person-dependent trait (Chow et al., 2008; Koenig & Harris, 2005). Taken together, these findings will inform future researchers about infants' ability to keep track of an individual's history of credibility and use it to guide subsequent learning that extends beyond the domain of theory of mind tasks. In addition, these findings will also inform researchers whether infants can determine the most reliable source of information based on whether a person has had the right kind of perceptual access to information.

A better understanding of the scope of infants' epistemic trust could also be achieved by examining the use of alternative training tasks since the current studies only used the search task as a method of reliability training. Although findings from the unreliable looker group revealed that both 14- and 16-month-old infants developed an expectation that there was nothing to see inside the container, future studies may explore alternative ways by which infants could learn about a person's reliability. It would be interesting to examine whether the current findings in gaze following and expectation in search behavior would be replicated if the unreliable figure were to mislabel a familiar object or demonstrate inaccurately the function of familiar objects.

Another potential direction for future research involves looking at the longitudinal link between early performance on theory of mind tasks, such as infants' performance on the gaze following and true belief tasks following reliability training, and their performance on reliability tasks at the preschool age. For example, it would be of interest to explore whether infants' success on the gaze following and true belief tasks also predicts preschool performance on an object-labeling task. That is, will infants who are

sensitive to the reliability of a person's gaze at 14 months also prefer to seek and endorse labels provided by someone who had been previously shown to be accurate rather than inaccurate or ignorant? In this way, these results will help clarify the continuity between social cognition between infancy and early childhood and will provide additional evidence of infants' early understanding of visual perception and beliefs. Specifically, this line of research will help inform whether infants' ability to attribute visual perception and beliefs to a looker on the basis of a person's prior record of reliability is related to their later ability to distinguish between a reliable and unreliable informant in active verbal tasks.

Finally, another interesting question for future research would be to explore the link between emotional trust and epistemic trust. Previous research with preschoolers indicates that a child's attachment security to a parent influences a child's preference for naming an unfamiliar object (Corriveau & Harris, 2009). In particular, when children were presented with conflicting names for objects by their mother and a stranger and the perceptual cues were equally consistent with both claims, children who had an insecure-avoidant attachment with their mother favored the claims made by the stranger whereas children who had a secure attachment preferred the mother's claim. These findings suggest that attachment status has a direct impact on the degree to which children rely on information supplied by the mother. However, it remains to be determined whether infants use the emotional cues of an unreliable looker to appraise uncertain events? Answers to this question will help address whether infants' cognitive profile of the informant's reliability will extend to an emotional profile.

In summary, the current studies represent an important new approach to clarifying a longstanding debate in the literature concerning the depth of interpretation of infants' gaze following and looking time behaviours in theory of mind tasks. In particular, examining the effect of an agent's reliability on infants' attribution of visual perception and beliefs represents a novel approach by which to tease apart the use of low level strategies, such as learned behavioural rules, or a more mentalistic explanation to account for infants' gaze following and looking time behaviours. The findings from the present dissertation offer exciting new insights to the field of cognitive development by revealing for the first time infants' sensitivity to a person's past record of reliability, when previous research has focused predominantly on preschooler's sensitivity to an informant's reliability. Specifically, infants were able to take into account the reliability of a person's past gaze behaviour when attributing visual perception and beliefs in two different theory of mind tasks. Overall, these findings provide valuable insight regarding young infants' understanding of trust and how that interacts with infants' developing knowledge of naïve psychology.

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Appendix A

Sample Recruitment Letter

(Chapter 2)

August 2005

Dear Parents,

The Child Development Laboratory at Concordia University is involved in a study looking at infants' early understanding of other people's mental states, such as their visual perception. This research is funded by the Natural Sciences and Engineering Research Council of Canada. The Commission d'Accès à l'Information du Québec has kindly given us permission to consult birthlists provided by the Régie Régionale de la Santé et des Services Sociaux de la Région de Montréal-Centre. Your name appears on the birthlist of June 2005, which indicates that you have a child of an age appropriate for our study.

The present investigation involves two tasks that look at infants' understanding of what other people see. In the first task, the experimenter will present your child with colorful containers that has either a small toy or nothing inside. The experimenter will look inside a container and say, "Wow!" Then, we will observe whether your child will choose to explore the containers offered by the experimenter. In the second task, your child will observe the same experimenter looking at different objects that are located either within the infant's direct line of sight, or are located behind a barrier that obstructs the infant's view. We will then examine whether your child moves to look at the object in these different locations. During both tasks, your child will be sitting in a child seat and you will be seated directly behind. We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality.

Overall, your participation will involve approximately one 45-minute visit to our laboratory at the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West. Appointments can be scheduled at a time which is convenient for you and your child, including weekends. Free parking is available on the campus and we will reimburse any other transportation costs at the time of your visit. Upon completion of the study, a Certificate of Merit for Contribution to Science will be given to your child, and a summary of the results of our study will be mailed to you once it is completed.

For the purposes of this study, we are looking for infants who are 14 months of age, who hear English or French spoken in the home, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Virginia Chow or Aguy Moryoussef at 848-2424 ext. 2279, or Dr. Diane Poulin-Dubois at 848-2424 ext. 2219. We will try to contact you by telephone within a few days of your receipt of this letter

We are looking forward to speaking with you in the near future.
Sincerely yours,

Diane Poulin-Dubois, Ph.D.
Professor
Department of Psychology

Virginia Chow, M.A.
Ph.D. Candidate
Department of Psychology

Appendix B

Sample Consent Form

(Chapter 2)

Parental Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois, in collaboration with students Virginia Chow, Jessica Lewis and Alla Sorokin of Concordia University.

A. PURPOSE
I have been informed that the purpose of the research is to examine infants' understanding of other people's mental states, such as their visual perception.

B. PROCEDURES
The present investigation examines infants' understanding of the process of seeing. That is, do infants understand that when we look at something and express interest, it is because we are looking at something interesting? This study involves two tasks. In the first task, an experimenter will present your child with colorful empty containers. The experimenter will look inside a container and say, "Wow!" Then, we will observe whether your child choose to explore the container offered by the experimenter. In the second task, your child will observe the same experimenter looking at different objects that are located either within the infant's direct line of sight, or are located behind a barrier that obstructs the infant's view. We will then examine whether their prior learning experience will influence your child's ability to look at the object in these different locations. During these tasks, your child will be sitting in a child seat and you will be seated directly behind. We will videotape both tasks and all tapes will be treated in the strictest of confidentiality. That means that the researcher will not reveal your child's identity in any written or oral reports about this study. Your child will be assigned a coded number, and that number will be used on all materials collected in this study. As well, because we are only interested in comparing children's understanding as a function of age, no individual scores will be provided following participation. The entire session is expected to last approximately one hour.

C. RISKS AND BENEFITS
Your child will be given a certificate of merit at the end of the session as a thank-you for his/her participation.

There is one condition which may result in the researchers being required to break the confidentiality of your child's participation. There are no procedures in this investigation that inquire about child maltreatment directly. However, by the laws of Québec and Canada, if the researchers discover information that indicates the possibility of child maltreatment, or that your child is at risk for imminent harm, they are required to disclose this information to the appropriate agencies. If this concern emerges, the lead researcher, Dr. Diane Poulin-Dubois, will discuss the reasons for this concern with you and will advise you of what steps will have to be taken.

D. CONDITIONS OF PARTICIPATION
- I understand that I am free to withdraw my consent and discontinue my participation at any time without negative consequences, and that the experimenter will gladly answer any questions that might arise during the course of the research.
- I understand that my participation in this study is confidential (i.e. the researchers will know, but will not disclose my identity).
- I understand that the data from this study may be published, though no individual scores will be reported.

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOUNTARILY AGREE TO HAVE MY CHILD PARTICIPATE IN THIS STUDY.

MY CHILD'S NAME (please print) _____

MY NAME (please print) _____

SIGNATURE _____ DATE _____

WITNESSED BY _____ DATE _____

I would be interested in participating in other studies with my child in the future (yes/ no): _____

If at any time you have questions about your rights as a research participant, you are free to contact Adela Reid, Research Ethics and Compliance Officer, Concordia University, at (514) 848-2424 ext 7481 or by email at areid@alcor.concordia.ca

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Participant # _____ Researcher: _____

Participated in other studies during the same visit:

Name of study	Subject #	Tested by

Appendix C

Demographic Questionnaire

(Chapter 2 and Chapter 3)

Participant Information

Infant's first name: _____ Date of Birth: _____

Infant's last name: _____ Gender: _____

Language(s) spoken at home (and other places):_____

Mother's first name: _____ Father's first name: _____

Mother's maiden name: _____ Father's last name: _____

Address: _____ Telephone #:_____home

City: _____ _____work mom

Postal Code:_____ _____work dad

E-mail: _____

Mother's occupation:_____ Father's occupation:_____

Mother's education (highest level attained):_____

Father's education (highest level attained):_____

Mother's marital status:_____ Father's marital status:_____

Please answer the following general information questions about your child:

Birth weight:_____ Length of pregnancy:_____weeks

Birth order:_____(e.g., 1 = 1st child)

Number of children in family:_____

Were there any complications during the pregnancy?_____

Has your child had any major medical problems?_____

Does your child have any hearing or vision problems?_____

** Have you ever been contacted by another university to participate in one of their studies? (Yes/No): _____

** If you answered yes, please name the university: _____

Participant # :_____ Researcher:_____

Appendix D

Instructions Given to Parents

Instructions to Parents

Search Task

1. When we will enter into the testing room, please seat your child on the clip-on chair attached to the table. You will be seated directly behind your child.
2. Before starting the study, we will ask that you please make sure that your child is not holding any toy or eating any food, as this could distract him/her.
3. Throughout the study, please do not communicate with your child (i.e., making gestures to look ahead)
4. Often, children will turn away from the experimenter and look toward you. If this happens, just smile at your child. After a few moments, they will turn back to face us.
5. If your child will cry or becomes upset, we will interrupt the study so that you can reassure your child.

Gaze Following Task

1. In the gaze following task, you will be seated on a stool with your child directly in front of you. You and your child will be seated facing a barrier. When the experimenter has finished giving the demonstration for the task, she will say, "Ok" to let you know that you could let your child go to roam around.
2. After the experimenter has shown the child the toy hidden behind the barrier, she will ask you to take your seat with the child again to begin the demonstration for the next barrier.

Appendix E

Coding Form for Search Task

(Chapter 2 and Chapter 3)

Search Task – CODING SHEET
(Based on Repacholi, 1998; Chow, Poulin-Dubois, & Lewis, 2008)

Participant #	
Date of Birth	
Condition	☐ Trustworthy ☐ Nontrustworthy

Date Coded	
Coded by	
Gender	☐ Male ☐ Female

Warm-Up Phase

Trial	Opened Lid (Y or N)	Examined Content (Y or N)
1	_____	_____
2	_____	_____

Training Phase: **Examination Score:** _____ / 4
trials

Trial	Color of Container	Opened Lid (Y/N)	Examined Content (Y or N)	Pushed Away (Y or N)	No Response (Y or N)
1	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____
4	_____	_____	_____	_____	_____

Comments:

Appendix F

Coding Form for the Gaze Following Task

(Chapter 2)

Gaze Following Task – CODING SHEET
(Based on Moll & Tomasello, 2004; Chow, Poulin-Dubois, & Lewis, 2008)

Participant #		Date Coded	
Condition		Coded by	

Gaze Following:

Trial	Barrier	Choice of Experimenter (Trustworthy/Non-Trustworthy)	Direction of Look (In front/Behind)	Does the Child Follow Gaze? (Yes/No)
1.				
2.				
3.				
4.				

Criteria for approaching an experimenter:

1. The child moves toward the target location (sticker or toy) where the trustworthy experimenter had gazed or where the non-trustworthy experimenter had gazed

Criteria for gaze following behind barrier:

1. The child moves the distance until he/she has visual access to the back of the barrier
2. The child looks to the target location where the Person or Robot has gazed (in the case of the red bucket, the child leans forward and looks inside of the bucket)

Criteria for gaze following in front of the barrier:

1. The child moves and looks at the sticker on the barrier.

Total:

TOTAL (out of 4)	Gaze Following
Experimental Trials (Behind)	
Control Trials (In front)	

Appendix G

Sample Recruitment Letter

(Chapter 3)

March 2007

Dear Parents,

The Child Development Laboratory at Concordia University is involved in a study examining infants' early understanding of other people's mental states, such as their visual perception. This research is funded by the Social Sciences sand Humanities Research Council of Canada. The Commission d'Accès à l'Information du Québec has kindly given us permission to consult birthlists provided by the Régie Régionale de la Santé et des Services Sociaux de la Région de Montréal-Centre. Your name appears on the birthlist of November 2005, which indicates that you have a child of an age appropriate for our study.

The present investigation involves two tasks that examine infants' understanding of what other people see. In the first task, a female experimenter will present your child with colorful containers that have either a small toy or nothing inside. The experimenter will look inside a container and say, "Wow!" Then, we will observe whether your child will choose to explore the containers offered by the experimenter. In other words, half the infants will link the experimenter's looking behavior with an object and the other half will not. In the second task, your child will observe the same experimenter hide a toy in one of two boxes and then reach for the hidden toy either in the correct location or in the incorrect location. Infants' looking time during these events will be measured to examine whether their prior learning experience will influence their ability to predict where the experimenter should look for the toy. During both tasks, your child will be sitting in a child seat and you will be seated directly behind. We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality.

Overall, your participation will involve approximately one 45-minute visit to our laboratory at the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West. Appointments can be scheduled at a time which is convenient for you and your child, including weekends. Free parking is available on the campus and we will reimburse any other transportation costs at the time of your visit. Upon completion of the study, a Certificate of Merit for Contribution to Science will be given to your child, and a summary of the results of our study will be mailed to you once it is completed.

For the purposes of this study, we are looking for infants who are 15-16 months of age, who hear English or French spoken in the home, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Virginia Chow or Alla Sorokin at 848-2424 ext. 2279, or Dr. Diane Poulin-Dubois at 848-2424 ext. 2219. We will try to contact you by telephone within a few days of your receipt of this letter

We are looking forward to speaking with you in the near future.
Sincerely yours,

Diane Poulin-Dubois, Ph.D.
Professor
Department of Psychology

Virginia Chow, M.A.
Ph.D. Candidate
Department of Psychology

Appendix H

Sample Consent Form

(Chapter 3)

Parental Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois, in collaboration with students Virginia Chow, and Amanda Guay of Concordia University.

A. PURPOSE

I have been informed that the purpose of the research is to examine infants' understanding of other people's mental states, such as their visual perception.

B. PROCEDURES

The present investigation examines infants' understanding of the process of seeing. That is, do infants understand that when we look at something and express interest, it is because we are looking at something interesting? This study involves two tasks. In the first task, an experimenter will present your child with colorful empty containers. The experimenter will look inside a container and say, "Wow!" Then, we will observe whether your child choose to explore the container offered by the experimenter. In the second task, your child will observe the same experimenter hide a toy in one of two boxes and then reach for the hidden toy either in the correct location or in the incorrect location. We will then examine whether their prior learning experience will influence their expectation regarding where the experimenter will look for her toy. During these tasks, your child will be sitting in a child seat and you will be seated directly behind. We will videotape both tasks and all tapes will be treated in the strictest of confidentiality. That means that the researcher will not reveal your child's identity in any written or oral reports about this study. Your child will be assigned a coded number, and that number will be used on all materials collected in this study. As well, because we are only interested in comparing children's understanding as a function of age, no individual scores will be provided following participation. The entire session is expected to last approximately one hour.

C. RISKS AND BENEFITS

Your child will be given a certificate of merit at the end of the session as a thank-you for his/her participation.

There is one condition which may result in the researchers being required to break the confidentiality of your child's participation. There are no procedures in this investigation that inquire about child maltreatment directly. However, by the laws of Québec and Canada, if the researchers discover information that indicates the possibility of child maltreatment, or that your child is at risk for imminent harm, they are required to disclose this information to the appropriate agencies. If this concern emerges, the lead researcher, Dr. Diane Poulin-Dubois, will discuss the reasons for this concern with you and will advise you of what steps will have to be taken.

D. CONDITIONS OF PARTICIPATION

- I understand that I am free to withdraw my consent and discontinue my participation at any time without negative consequences, and that the experimenter will gladly answer any questions that might arise during the course of the research.
- I understand that my participation in this study is confidential (i.e. the researchers will know, but will not disclose my identity).
- I understand that the data from this study may be published, though no individual scores will be reported.

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOUNTARILY AGREE TO HAVE MY CHILD PARTICIPATE IN THIS STUDY.

MY CHILD'S NAME (please print) _____

MY NAME (please print) _____

SIGNATURE _____ DATE _____

WITNESSED BY _____ DATE _____

I would be interested in participating in other studies with my child in the future (yes/ no): _____

If at any time you have questions about your rights as a research participant, you are free to contact Adela Reid, Research Ethics and Compliance Officer, Concordia University, at (514) 848-2424 ext 7481 or by email at areid@alcor.concordia.ca

Diane Poulin-Dubois, Ph.D.	Virginia Chow, M.A.	Amanda Guay
Professor	Ph.D. Candidate	Undergraduate Student
Department of Psychology	Department of Psychology	Department of Psychology
848-2424 ext.2219	848-2424 ext.2279	848-2424 ext.2279
diane.poulindubois@concordia.ca	vchow@alcor.concordia.ca	jessi_le@alcor.concordia.ca

Participant # _____ Researcher: _____

Participated in other studies during the same visit:

Name of study	Subject #	Tested by

Appendix I

Coding Form for the True Belief Task

(Chapter 3)

True Belief Study (16 months)
Coding Duration of Eye Gaze during Test Trial
(Based on Onishi & Baillargeon, 2005; Poulin-Dubois & Chow, in press)

Subject Number: _____ Coded by: _____
Order: _____ Date coded: _____

Comments:

_____

_____

_____

_____

****NOTE: coding should be done from the experimenter's perspective

Congruent	Incongruent	Experimenter	Outside Display	Total Time	What side was target toy on?