# Infants' Concept of Intention: Investigating Inter-task Relations and Developmental Continuities

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## ABSTRACT

**Infants' Concept of Intention: Investigating Inter-task Relations and Developmental Continuities**

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The objective of the present thesis was to examine infants' understanding of other people's intentions. The first paper was designed to systematically investigate whether the tasks currently being used to tap into infants' understanding of intentional action are actually measuring the same underlying abilities. Infants completed two visual attention tasks when they were 10 months of age: a goal-detection task and an action-parsing task. Approximately four months later, infants were invited back to the laboratory to complete two imitation tasks: a behavioral re-enactment task and a selective action imitation task. Infants' concurrent performances on the visual attention tasks were linked; however, no association between their performances on the imitation tasks was observed. Interestingly, infants' performances on the visual attention tasks at 10 months predicted their performance on the behavioural re-enactment task, but not their performance on the selective action imitation task, at 14 months.

In the second paper, the issue of developmental continuities was explored. The goal of this paper was to investigate whether infants' performance on the selective imitation of intentional actions task would predict their use of internal state language and/or their theory of mind abilities later on. Towards this purpose, 14- and 18-month-olds completed an imitation task that required them to distinguish intentional from accidental actions. At approximately 32 months, children's use of internal state terms was

assessed via parental report. Finally, when children were 4 years of age, they were re-tested with an interactive game measuring intention understanding, a battery of general theory of mind tasks, and the Peabody Picture Vocabulary Test. Importantly, infants' performance on the selective action imitation task was linked to their performance on the preschool intention task. Moreover, children's use of internal state language at 32 months predicted their theory of mind skills at 4 years of age. Taken together, the results of the present thesis support the hypothesis that there is developmental continuity in children's understanding of intention from infancy through the preschool years. Results from these two papers also provide evidence to support the validity of various experimental procedures that are currently being used to tap infants' understanding of intentional action.

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# Chapter 1: General Introduction

Adults make inferences about other people's behavior every day, a process that entails a form of naïve psychology. Naïve psychology (also known as "theory of mind" and/or folk psychology) involves having some understanding that people have internal, subjective mental states (i.e., desires, intentions, and beliefs) that can explain and predict behavior. For instance, if we see someone walking slowly down the aisle of a department store, with their head bent low and their eyes scanning the floor, we may attribute this person the following mental states: (1) this person *wants* to find something she has lost (desire), (2) this person *intends* to find the missing object by searching the floor of the department store (intention), and (3) this person *believes* that the object she has lost may be located on the floor (belief). Remarkably, adults are able to attribute mental states to other people with little conscious effort. These mental reasoning skills help foster other advanced human abilities such as displaying empathy (Barr, 2006) and interpreting jokes or sarcasm (Leekam, 1991).

For the past two decades, cognitive developmental scientists have been investigating when and how children develop a similar understanding of the mind. Most researchers agree that a critical milestone in theory of mind development is gaining the ability to attribute false beliefs. In order to truly understand the concept of false belief, one must realize the following: (1) how beliefs are formed, (2) that people's mental representations of the world can be different from one's own and do not necessarily reflect reality, and (3) that people's behavior can be predicted and/or explained by their mental states (i.e., beliefs). Wimmer and Perner (1983) were the first researchers to design a task that taps into children's understanding of false belief. Since then, numerous versions of this standard false belief task have been created. In a typical false belief task, the experimenter tells the child a story using pictures and toy figurines. For example, in the "Sally-Ann Transfer Task" (Baron-Cohen, Leslie, & Frith, 1985), the child is told a story about two characters (i.e., Sally and Ann) playing with a toy. Sally and Ann put the toy in a box, and then Sally leaves. Ann stays in the room and removes the toy from the box in order to play with it again. When she is finished, she puts it away in a different box. Sally returns, and the child is asked where she will search for the toy. To pass the task, the child must recognize Sally's false belief about the situation and look in the box where she initially put the toy. The child fails the task if he/she indicates that Sally will look in the second box, where the child knows the toy is hidden. Children who pass the false belief task understand that another person's belief about a situation can differ from their own, and they are able to predict that person's behavior based on this knowledge. Several studies have shown that, by the time children reach 4 or 5 years of age, they are able to reliably pass the false-belief task (Wellman, Cross, & Watson, 2001). As such, children this age are thought to have a representational understanding of the mind.

Although this level of understanding does not emerge until 4 or 5 years of age, a substantial number of studies have indicated that even 2- and 3-year-olds have some form of folk psychology (e.g., Bartsch & Wellman, 1995). For example, 2-year-olds can predict other people's actions based on their expressed desire (Wellman & Woolley, 1990) and they understand the link between other people's desires, perceptions, and emotions (Wellman, Phillips, & Rodriguez, 2000). Furthermore, 3-year-olds recognize that people act intentionally in order to achieve an outcome, and they can distinguish intentional actions from other non-purposeful actions such as accidents or movements due to reflexes or gravity (Call & Tomasello, 1998; Schult & Wellman, 1997; Shultz, 1990). Some researchers have suggested that younger children may also have some implicit understanding of false belief, but fail the canonical test of theory of mind (i.e., false belief task) because of the excessive language and computational demands inherent in the task (Bloom & German, 2000; Chandler, Fritz, & Hala, 1989; Fodor, 1992; Premack & Premack, 1995). Children under 4 years may also fail the classic false belief tasks because of poor inhibitory control (e.g., Carlson, Moses, & Hix, 1998) and the so-called reality-bias (i.e., young children's own knowledge about a situation has been found to interfere with their ability to answer correctly)(Birch & Bloom, 2003; Leslie, German, & Polizzi, 2005; Mitchell & Lacohee, 1991). Indeed, investigators have shown that 2- and 3-year-olds are able to pass modified versions of the false-belief task when they are simply required to look, rather than say, where the character will search for her toy (Clements & Perner, 1994; Garnham & Ruffman, 2001). For example, in a recent study, Southgate, Senju, and Csibra (2007) presented 25-month-olds with movies in which an actor watched a toy being hidden. When the actor was looking away, the location of the toy was switched. In order to examine children's ability to attribute false-belief, the investigators used an eye-tracker to encode 25-month-old infants' anticipatory looking behavior. Interestingly, when the actor re-oriented infants towards the scene, they reliably looked towards the location that she would search for the toy if she had a false-belief. These results provide evidence to suggest that children as young as 25 months may possess the ability to attribute false beliefs.

Such findings have prompted researchers to take a closer look at how children first begin to construe others as psychological beings. As such, cognitive developmental scientists' have begun to examine putative precursors to theory of mind development in infancy. One of the earliest, and most important, building blocks for theory of mind may be infants' special interest in other people. From the moment they are born, infants differentially attend to human faces, voices, and movement (Flavell, 2004). They also seem motivated to interact with other people. For instance, when they are 6 to 8 weeks old, infants smile in response to an adult's behavior (Hains & Muir, 1996). Intuitively, it makes sense that theory of mind development begins with infants' inherently strong desire to learn about people.

Another precursor to theory of mind that has been identified among newborns is their ability to attend to, and imitate, other people's behavior. Research has shown that newborn infants can imitate another person's tongue protrusions reliably (Meltzoff & Moore, 1977). According to Meltzoff (1999), early imitation is pertinent to theory of mind because it requires infants to make a connection between their own internal states and the observable world of other people. Thus, infants' early abilities to imitate other people's actions may represent an important step towards developing a full-fledged theory of mind.

Other potential building blocks for theory of mind include infants' abilities to follow gaze and detect the goals underlying people's behavior. By the end of the first year, infants are sensitive to goal-directed action and they can identify the goals of other people using cues such as eye gaze and emotion (Baird & Baldwin, 2001; Gergely, Nadasdy, Csibra, & Biro, 1995; Phillips, Wellman, & Spelke, 2002; Woodward, 1998). These abilities are said to represent infants' understanding of intention in action. Furthermore, these skills are important because they are necessary for joint attention, another putative precursor for theory of mind. Joint attention occurs when two individuals engage in a triadic interaction. That is, when two people simultaneously attend to each other and some object of interest (D'Entremont, Yazbek, Morgan, & MacAulay, 2007). Joint attention has been identified as a building block for theory of mind because it requires the infant to have some understanding that other people have perspectives and intentions (Bretherton, 1991). Indeed, some theorists argue that infants' gaze following and joint attention skills emerge at the same time as their realization that people are intentional beings (Carpenter, Nagell, & Tomasello, 1998; Tomasello, 1995).

Recent research has focused on infants' understanding of intentionality as one of the earliest precursors for theory of mind. Intention can be used to denote deliberate action as opposed to accidental action (i.e., people do things intentionally) and to refer to the reason why something is done (i.e., people intend to do things; Astington, 2001). Unlike complex mental states such as belief, intentions do not involve representations or interpretations of the world. Instead, they reflect attitudes towards the external world or relations with it (Astington, 2001). Because intentions may be construed non-representationally, they may be easier to understand. Indeed a developmental progression from understanding desires and intentions to understanding beliefs has been reported during the preschool period (Astington & Gopnik, 1991; Gopnik, 1993; Wellman, 1990, 1993). There have been numerous studies examining infants' understanding of intention in action and intention in the mind. For example, investigations have shown that infants can segment continuous human actions into units that coincide with an actor's intentions (e.g., Baird & Baldwin, 2001), make inferences about the goals underlying other people's behavior (e.g., Behne, Carpenter, Call, & Tomasello, 2005; Meltzoff, 1995), and preferentially imitate intentional over accidental actions (Carpenter, Akhtar, & Tomasello, 1998; Olineck & Poulin-Dubois, 2005). These studies all indicate that infants possess some form of intention understanding early on.

Taken together, research on putative precursors of theory of mind has provided strong evidence for the notion that theory of mind emerges gradually. As a result, most cognitive developmental scientists now emphasize a developmental perspective when studying theory of mind (e.g., Sodian & Thoermer, 2008; Wellman & Lagattuta, 2000). However, in a recent controversial study, Onishi and Baillargeon (2005) suggested that 15-month-old infants may already have a representational understanding of the mind. These researchers designed a nonverbal false belief task, based on the violation of expectation paradigm. Infants were shown movies depicting an actor hiding a toy in one of two boxes. After a familiarization period, infants' witnessed a change that resulted in the actor having a true or false belief about the location of the toy. During the test trial, infants observed the actor put her hand in one of the two boxes and their looking time was coded. Onishi and Baillargeon (2005) found that infants expected the actor to search for her toy in the box that she believed it to be hidden and they were surprised (i.e., looked significantly longer) when she did not. Based on these results, Onishi and Baillargeon (2005) concluded that 15-month-olds possess an implicit rudimentary understanding of false belief.

Onishi and Baillargeon's (2005) paper fueled the contentious debate that exists among cognitive developmental scientists concerning: (1) how these types of infant behaviors should be interpreted, and (2) the depth of infants' understanding of the mind. Some investigators (such as Onishi & Baillargeon, 2005) favor rich interpretations, crediting infants with some understanding of mental states. Others prefer leaner, less mentalistic, explanations of infants' action. For instance, it has recently been argued that infants' abilities to predict how a person will act could be based simply on learned rules about behavior rather than on a conception that the mind mediates behavior (Perner & Ruffman, 2005). Sirois and Jackson (2007) have also criticized Onishi and Baillargeon's (2005) rich interpretation by highlighting methodological confounds and statistical limitations inherent in their study. For example, these researchers posited that infants' looking times on the belief-induction trials may have reflected their sensitivity to perceptual variations among these trials (e.g., objects moved, direction of movement) rather than their conceptual knowledge per se. According to Sirois and Jackson (2007), future research using Onishi and Baillargeon's (2005) design should employ a statistical approach based on regression analyses in order to examine infants' looking time patterns more closely. From Sirois and Jackson's (2007) perspective, the field has yet to provide compelling evidence that infants possess some high-order social cognitive abilities.

One way to clarify the depth of infants' understanding of the mind is to determine whether there is continuity between infants' early social-cognitive abilities and their later, more advanced, theory of mind skills. If infants have some basic knowledge of mental states, their performance on tasks tapping into early theory of mind should be linked to their performance on theory of mind tasks administered in the preschool years. Such correlations would provide empirical evidence to support the notion that children gradually converge on an "adult-like" theory of mind. To date, only a handful of longitudinal studies on naïve psychology development have been conducted. Recent investigations have focused on examining the association between infants' attention to human action, as measured by infant habituation paradigms, and later theory of mind. For example, Wellman, Phillips, Dunphy-Lelii, and Lalonde (2004) tested 14-month-olds using a preferential looking task designed to examine infants' understanding of people's behavior from their gaze and facial expressions (Phillips et al., 2002). When these infants were approximately 4 years old, they were re-tested with a battery of theory of mind tasks (i.e., Theory of Mind Scale, Wellman & Liu, 2004). Interestingly, Wellman and his colleagues (2004) found that that infants' decrement of attention to intentional action was positively correlated with their later theory of mind skills. Similar results were recently reported by Aschersleben, Hofer, and Jovanovic (in press), who found that infants' decrement of attention to goal-directed action at 6 months was positively correlated with their performance of a standard false-belief task at 4 years of age. It is possible that these longitudinal relations may simply reflect a tendency for more advanced infants to perform better on cognitive tasks in preschool (Wellman, Lopez-Duran, Labounty, & Hamilton, 2008). As such, Wellman et al. (2008) conducted a longitudinal study that included control tasks which were administered at the preschool age. Their results replicated previous findings in that infants' attention to human action was significantly linked to later theory of mind (as measured by the false belief task). Importantly, Wellman et al. (2008) found that this infant-to-preschool relation remained significant even when measures of more general cognitive processes (e.g., verbal competence, general IQ, and executive function) were controlled. These results provide evidence to support the hypothesis that there are longitudinal links between infant and preschool theory of mind abilities, when infant measures of attention during habituation are employed.

Are there similar longitudinal associations when other methodologies are used? Preliminary results from three studies suggest that there are. First, Youngblade and Dunn (1995) found that children who engaged in more pretend play when they were 33 months of age were better at identifying feelings and recognizing false beliefs 7 months later. Research has also uncovered associations between infants' joint attention abilities at 20 months and their performance on theory of mind tasks at 44 months of age (Charman et al., 2000). Finally, Olineck and Poulin-Dubois (2005) found that infants who were more likely to imitate intentional actions at 14-18 months had a larger internal state lexicon at 32 months. Further research is needed to determine whether there is continuity between infants' social cognitive abilities and later theory of mind, regardless of what methodology is used. In addition to clarifying the developmental progression of theory of mind from infancy to childhood, it is important for cognitive developmental scientists to critically examine the validity of the tasks being used to tap into preverbal infants' understanding of the mind.

One way of obtaining empirical evidence to support the validity of these nonverbal methodologies is to determine whether infants' performances on tasks that are presumably tapping into related constructs are related. The first paper of the present dissertation sought to address this issue by investigating whether infants' performances on visual attention and imitation tasks are linked. A short-term longitudinal study of goal/intention understanding was conducted with infants from 10 to 14 months of age. The first objective of this study was to examine whether 10-month-old infants' performances on two visual attention tasks would be related to their performances on two imitation tasks administered four months later. The second objective of this study was to investigate whether there would be associations between infants' concurrent performances on the two visual attention tasks at 10 months and the two imitation tasks at 14 months. Results from this short-term longitudinal study provide preliminary evidence to support the validity of some infant intention tasks and lend credence to the developmental continuity hypothesis. However, a more stringent test of developmental continuity requires longer term follow-up, where children's theory of mind skills are examined in infancy and again during the preschool period.

The second paper in the present dissertation systematically addressed this issue by examining the relationship between children's imitation of intentional actions and general language skills in infancy, internal state language in toddlerhood, and theory of mind in the preschool period. For this study, children who initially participated in an imitation task when they were 14 or 18 months old, and whose parents provided information regarding their internal state lexicon at 32 months, were re-tested with a battery of theory of mind tasks when they were approximately 55 months old. This study was designed to examine whether there is a relationship between children's implicit understanding of intention in infancy and their more explicit understanding of intention during the preschool years. This research also investigated whether infants' performance on an intention task in the second year of life would be related to their general concept of mind later on, as measured by the false belief task and the Theory of Mind Scale (Wellman & Liu, 2004). Finally, this study examined whether there is continuity between young children's general language use, internal state vocabulary, and later theory of mind abilities. Together the two papers presented in this dissertation provide empirical evidence to support the validity of tasks currently being used to measure infants' early understanding of intention, as well as further investigate the hypothesis that there is continuity in social cognition between infancy and early childhood.

Chapter 2

# Infants' Understanding of Intention from 10 to 14 months: Inter-relations Among Visual Attention and Imitation Tasks

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## Contribution of Authors

This section describes the contributions made by the first author in the article entitled "Infants' understanding of intention from 10-14 months: Inter-relations among visual attention and imitation tasks". This experiment was conducted in the Cognitive Development Laboratory in the Centre for Research in Human Development at Concordia University, Montreal.

With respect to planning, the first and second author devised experimental methods and the research design collaboratively. In preparation for testing, the first author worked closely with a carpenter to create experimental stimuli (e.., replicates of the materials used by previous researchers). The first author also produced detailed scripts describing the action sequences and/or live demonstrations to be used during testing. The first author collaborated with a research assistant to create the digitized videos depicting action sequences that were used during one of the visual attention tasks. For this task, the first author also conducted a pilot study with 10 adult participants, in order to ensure the suitability of the stimuli used. The first author devised administration orders (i.e., counterbalancing) and worked with the research assistant to program the events into habituation software.

In terms of data collection, the first author wrote recruitment letters and consent forms for this study, in addition to recruiting English-speaking participants. Twenty-six participants were tested at 10 months and 20 of these infants returned to the laboratory when they were approximately 14 months of age. The first author was present for all of these testing sessions. With English-speaking families, the first author explained the study procedures and rationale to parents, and was actively involved in the administration of the experiment. With French-speaking participants (n=11), a research assistant explained the study procedures to parents, but the first author remained involved in the administration of the experiment (e.g., actor during live demonstration included in the goal-detection task). During the visual attention tasks, infants' looking times were coded live by a research assistant. For the imitation tasks, the first author coded children's behavior by re-watching recordings of the test session. A research assistant, who was not informed of the study hypotheses, re-coded the data for reliability purposes and re-entered the data to ensure its accuracy. The first author subsequently entered the data into an SPSS worksheet and conducted the analyses. The first author also wrote letters to parents describing the research findings and thanking them for their participation.

The first author wrote the abstract, methods, and results sections of this paper, with comments and revisions provided by the second author. The introduction and discussion sections of this paper were written by both authors collaboratively. This paper has been submitted for publication.

Abstract

The present study examined infants' understanding of other people's intentional actions. The primary goal was to investigate whether infants' performances on visual attention and imitation tasks that have been designed to tap understanding of intentional actions were interrelated. Infants completed a goal detection task and an action-parsing task at 10 months. At 14 months, infants completed a behavioral re-enactment task and a selective action imitation task that required infants to differentiate intentional from accidental actions. Infants' concurrent performances on visual attention tasks were linked; however, no association was found between their performances on imitation tasks. Importantly, infants' behaviors on the visual attention tasks predicted their performance on the imitation tasks at 14 months. These findings provide the first evidence that there is developmental continuity in infants' understanding of intentional action from 10 to 14 months.

Infants' understanding of intention from 10 to 14 months: Inter-relations among visual attention and imitation tasks

Over the past two decades, there has been an upsurge of studies focused on how children gradually converge on an adult-like folk psychology, or "theory of mind". It has been proposed that understanding intention may one of the first steps towards developing a theory of mind (Tomasello, Carpenter, Call, Behne, & Moll, 2005). Intention denotes deliberate action, and refers to the reason why something is done. Unlike complex mental states such as beliefs, intentions do not involve representations or interpretations of the world, but rather attitudes toward it or relations with it (Astington, 2001). As such, intentions may be construed non-representationally and may be easier to understand. Indeed, a developmental progression from understanding desires and intentions to understanding beliefs has been documented during the preschool period (Astington & Gopnik, 1991; Gopnik, 1993; Wellman, 1990, 1993; Wellman & Woolley, 1990).

An important issue to consider is the foundation of intention understanding in infancy. Researchers have used a number of different methodologies to empirically measure infants' early understanding of intention in action and intention in the mind. For example, some understanding of intentionality has been documented in children's use of internal state words in naturalistic settings (Bartsch & Wellman, 1995; Bretherton & Beeghly, 1982; Shatz, Wellman, & Silber, 1983). In a longitudinal study of the verbal productions of 10 children between 1 and 6 years, Bartsch and Wellman (1995) reported that children's conversations about the mind begin early with talk about desires and intentions (e.g., want, wish) and that words in relation to beliefs appear later on (e.g., believe, know). Recent investigations of the developmental precursors of intention understanding have revealed that this knowledge might be rooted in infants' analysis of people's actions.

There is mounting evidence that even preverbal infants show a nascent understanding of intentional actions (Woodward, 2005). Using visual attention paradigms, researchers have demonstrated that infants as young as 6 months are capable of making goal attribution using cues such as hand gestures, gaze, and facial expressions. In her seminal paper, Woodward (1998) habituated infants to a scene where a human hand reached into a stage to grasp one of two toys. In the test trials, the position of the toys was switched and the infants saw the hand reach for either the same toy via a different path or the other toy via the original path. The results showed that infants as young as 6 months looked significantly longer when a new toy was grasped (i.e., new goal) compared to when the same toy (i.e., old goal) was grasped, even if the path of the hand movement remained the same. When they are a few months older, infants are able to interpret gaze as goal-directed, regardless of whether the actor is also pointing to the object or not. Poulin-Dubois (1999) first examined this issue by presenting 18- to 30-month-old infants with video-taped events in which a person was shown looking and pointing at one of two objects. Each event was followed by the presentation of two still frames showing the actor grasping each of the two objects. Infants looked longer at the incongruent behavior (grasping the object not looked at) than the congruent behavior (grasping the object looked at). This finding suggested that infants expected the person to grasp the object that she had looked at previously and were surprised when the person reached for the previously ignored object. Using the habituation paradigm, a similar understanding that gaze involves a relation between a person and the object of his or her gaze has been demonstrated in infants as young as 12 months (Woodward, 2003). Studies indicated that younger infants responded in a similar manner when they are presented with events that were identical to the looking events except that the actor also grasped the toy (Phillips et al., 2002; Sodian & Thoermer, 2004). Thus, it would appear that infants understand the link between looker and object by the end of the first year.

Other recent studies have corroborated some form of "intention-in-action" understanding by examining infants' ability to identify, within a behavior stream, those components that coincide with an actor's initiation and completion of intentions. Research on adults' processing of complex human action indicates that viewers readily segment continuous everyday actions into units that coincide with an actor's goals and intentions (Newtson, 1973; Newtson & Engquist, 1976; Zacks, Tversky, & Iyer, 2001). Recently, researchers have examined whether infants as young as 10 months also segment continuous human action into units according to intentional boundaries (Baird & Baldwin, 2001; Baldwin, Baird, Saylor, & Clark, 2001). Results indicated that infants who had become familiar with videos depicting continuous sequences of everyday intentional actions (e.g., a woman reaches and grasps a towel on the kitchen's floor, then moves toward and places it on a towel rack) were subsequently relatively disinterested when motion was interrupted (i.e., paused) at points where intentions were fulfilled. In contrast, infants showed renewed interest when similar interruptions occurred in the midst of an actor's pursuit of intentions (Baird & Baldwin, 2001; Baldwin et al., 2001). These findings seem to suggest that infants as young as 10 months segment complex human behavior into units that coincide with the completion and initiation of intentional action. The extent of infants' action parsing skills was further examined in a recent study conducted by Saylor, Baldwin, Baird, and Labounty (2007). Infants ranging from 9 to 11 months were shown two simultaneous live events. Each live event involved an actor manipulating an object set (e.g., opening a drawer, placing a sock in a drawer). While the actors engaged in continuous purposeful action, auditory tones were presented. For one of the actors, the tones coincided with intention-relevant boundaries. For the other actor, random tones occurred in the midst of their action sequence. Interestingly, infants looked significantly longer at displays in which the auditory tone corresponded with the completion or initiation of an intentional action. This study provides further empirical evidence to suggest that young infants are sensitive to the intentional boundaries inherent in complex human action even in the case of novel actions. According to Baldwin and her colleagues (2001), it is possible that infants' early action parsing skills may be a prerequisite to the development of genuine intentional understanding.

Recently, Behne, Carpenter, Call, and Tomasello (2005) demonstrated that around 9 months of age, infants also make inferences about the goals underlying other peoples' body motions. In this innovative study, infants were offered a toy by a female experimenter. At times, the experimenter tried to pass the toy to the infant but was unable to do so (i.e., accidentally dropped the toy). Other times, the experimenter appeared to be "unwilling" to pass the toy to the infant (i.e., offered the toy and then pulled it back in a teasing manner). Behne et al. (2005) reported that 9-, 12-, and 18-month-olds were more impatient when the experimenter was unwilling to give the toy, compared to when she tried to pass the toy, but was unsuccessful. Because infants altered their responses according to their perceptions of the other person's goals, this investigation provides further evidence to suggest that infants have developed some understanding of "intention-in-action" by 9 months of age.

Investigators have also examined infants' understanding of intention by capitalizing on their tendency to imitate human actions. In one of the earliest and most direct tests of infants' understanding of other people's intentions, Meltzoff (1995) showed 18-month-old infants an actor who tried, but failed, to perform several actions on objects. When given the opportunity to imitate the model, infants performed the action the experimenter intended to do (but never actually did) as often as those who had seen a demonstration in which the actor achieved his goal. This experiment has been replicated and extended in two recent cross sectional and longitudinal studies that tested 12-, 15-, and 18-month-olds. There appears to be a developmental progression in infants' ability to infer goal from surface behavior between 12 and 18 months of age (Bellagamba, Camaioni, & Colonnesi, 2006; Bellagamba & Tomasello, 1999; Johnson, Booth, & O'Hearn, 2001). Another series of imitation studies have revealed similar changes in imitation understanding over the second year of life. Carpenter, Akhtar and Tomasello (1998) found that 14- to 18-month-olds were more likely to imitate an experimenter's intentional actions, after observing her randomly performing these two types of actions on an object. In order to systematically investigate a possible developmental progression similar to the one reported on the failed intention paradigm, Olineck and Poulin-Dubois (2005) recently replicated and extended these findings by testing separate groups of 14- and 18-month-old infants. They found that infants' ability to differentiate intentional from accidental actions becomes more robust in this age range.

Together, these studies indicate that infants possess some form of understanding of other people's intentional actions. However, it is possible that the various tasks that have been designed to tap into infants' early understanding of intention are actually measuring different abilities. In other words, researchers have yet to systematically investigate whether the tasks used to tap infants' understanding of intention are measuring the same underlying skills, as currently implied in the extant literature. The goal of the present study was to clarify whether infants' performance across different measures of intention are linked. To our knowledge, the current study is the first to address this important issue. A short-term longitudinal study of goal/intentional action understanding between 10 and 14 months of age was conducted. If, as many researchers have argued, imitation and visual attention tasks are all measuring the same underlying construct (i.e., intention), one might expect that performance on these tasks would be interrelated. First, when infants were 10 months of age, two visual attention tasks were administered: the goal detection task (based on Woodward, 2003) and the action-parsing task (based on Baldwin et al., 2001). At 14 months of age, infants returned to the laboratory to complete a behavioral re-enactment task (based on Meltzoff, 1995) and a selective action imitation task that required infants to differentiate intentional from accidental actions (based on Carpenter, Akhtar et al., 1998; Olineck & Poulin-Dubois, 2005). It was hypothesized that there would be associations between infants' concurrent performance on the two visual attention tasks at 10 months and the two imitation tasks administered at 14 months. It was also expected that there would be developmental continuity between infants' performances on tasks administered at 10 and 14 months.

## Method

### *Participants*

Twenty-six infants participated in a goal detection task and an action parsing task when they were 10 months of age. Four of these infants were excluded from initial analyses because they failed to habituate during one or both of the visual tasks (n=3) or because they did not complete the tasks (n=1). Therefore, 22 infants were included in the final sample for the goal detection and action parsing tasks (13 males, 9 females; $M$=10.50 months, $SD$=0.24, range=10.03-10.89 months). Approximately 4 months later, 20 of the infants included in the original sample returned to the laboratory to participate in 2 imitation tasks (11 males, 9 females; M=14.95 months, SD=0.49, range=14.10-15.85 months). During their second visit to the laboratory, parents also completed the MacArthur Short Form Vocabulary Checklist: Level II Form A (MCDI: Fenson et al., 2000). Infants were recruited from birth lists provided by a governmental health 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 and Apparatus*

*Goal detection task.* The materials that were used included a child seat attached to a table that faced a stage, which was approximately 90 cm away. On the stage, a multicolored ball and a brown and white toy dog were positioned approximately 28 cm apart. An actor sat behind the stage. Above her head, a video lens was projected through a small hole in the back curtain of the stage, and was focused on the infant's face. During the testing session, an observer monitored the infant's visual fixation from behind the stage, using the video monitor and recording this information by pressing keys on the computer keyboard. The computer program Habit© (version 7.8) was used to record infant's looking times and calculate when the habituation criterion was met.

*Action parsing task.* The materials that were used included a child seat attached to a table enclosed on three sides by a black wooden partition. On the table, approximately 1 meter in front of the child was a computer monitor (43.2 cm). Directly above the computer monitor was a camera lens that protruded through a small hole in the partition and was focused on the infant's face. During the testing session, the experimenter monitored the infant's visual fixation from behind the front panel, using the video monitor and recording this information by pressing keys on the computer keyboard. The computer program Habit© (version 7.8) was used to present the movies on the monitor, record infant's looking times, and calculate when the habituation criterion was met.

Infants were presented with two movies in which the same female actor was shown performing a sequence of simple actions using different toy props. The actor wore a red long-sleeved shirt and the backgrounds of both movies were black. In the habituation phase, infants were presented an 8 sec movie that displayed the actor performing a continuously flowing action. Once the infant had habituated to this movie, he/she was shown two different versions of the same movie. Both versions had a 1.5 sec still frame pause inserted at some point during the course of action. In the "completed" test video, the still frame pause was inserted at a point in time that corresponded with the completion of an intentional action. In the "interrupted" test video, the still frame pause was inserted at a point in time that did not correspond with the completion of an intentional action.

In one action sequence, the actor was shown looking straight ahead, turning her head down and to the right to look at a toy truck that was positioned at the top of a ramp, extending her arm out, touching the truck with her hand, reaching her hand back, and then moving her hand forward to push the truck down the ramp. Her hand remained in the final position as the toy truck rolled down the ramp and out of sight. In the "completed test video" that corresponded with this movie, a 1.5 sec pause was inserted just after the actor's hand touched the truck. In the "interrupted test video" that corresponded with this movie, a 1.5 sec pause was inserted just before her hand touched the truck. In the other action sequence, the same actor was shown looking straight ahead, turning her head down and to the right to look at a column of toys, reaching her arm out, grasping the top toy, lifting the toy up and off the column, and then dropping it into a container. Her hand stayed in the final position as the toy dropped from her hand and disappeared into the container. In the "completed test video" that corresponded with this movie, a 1.5 sec pause was inserted just after the actor grasped the toy. In the "interrupted test video" that corresponded with this movie, a 1.5 sec pause was inserted just before she grasped the toy. Each action sequence included only background noises that resulted from the action taken on the objects (e.g., sounds linked to pushing a truck down a ramp, or dropping a toy into a container). During a pilot study, 10 adult participants were shown the test movies and then asked to complete a brief questionnaire (e.g., during this movie, did you see a pause in the motion displayed by the agent? If yes, please indicate the segment of the movie where you believe the pause occurred by endorsing one of the four options). Adults' responses to this questionnaire confirmed that the still-frame pauses inserted in the test movies either coincided with the completion of an intentional action or interrupted intentional action prior to completion.

An additional film was used to reorient the infant's attention to the screen between trials. This "attention-getter" stimulus consisted of a computer-generated picture of a green circle expanding and contracting as the "ding" of a bell was repeated once per second.

*Selective action imitation task.* The materials used for this task were the same as those used in Olineck and Poulin-Dubois (2005). A rectangular wooden box (38 cm long, 25 cm wide, 9 cm tall) with six removable lids was designed. Embedded in the center of each of the box lids were toy devices that could be easily manipulated by the infant (e.g., handle that twists). Two of the box lids were always used in the warm-up phase of testing and the remaining four lids were randomly assigned to four experimental trials. One of the lids used in the warm-up phase of testing included one toy device and the remaining five box lids included two toy devices that were matched for size and level of attractiveness. The base of the box was visibly connected to a computer monitor via a telephone cord. Following the action demonstration, computer animations were surreptitiously activated by the experimenter and were displayed on the monitor.

*Behavioral re-enactment task.* The materials used for this task closely resembled those used by Meltzoff (1995) and Bellagamba et al. (2006). Three colorful blocks were used during the warm-up phase. For the experimental trials, five novel object sets were used. Each of these objects consisted of at least two components that could be used to complete a target action. The object sets were: (1) a dumbbell that could be separated into two pieces, (2) a button embedded into a box that could be activated with a wooden wand, (3) a loop that could be hung around a horizontally protruding prong, (4) a string of beads that could be put into a cylinder, and (5) a transparent plastic square with a hole that could be placed over a wooden dowel.

*Procedure and Design*

During both laboratory visits (i.e., time 1=10 months, time 2=14 months), participants were greeted by the experimenter and brought to a reception area. 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), filled out a demographic questionnaire (see Appendix C), and completed the MCDI (i.e., during their second visit to the laboratory). Parents were also provided instructions regarding their behavior during the testing session (see Appendix D). Specifically, parents were discouraged from redirecting their infants back to the visual displays or encouraging them to complete any actions. After the familiarization period, infants were brought to the testing room and seated in a child's seat attached to a table. Their parent sat directly behind them. During the goal detection and action parsing tasks, the lights in the testing room were dimmed to ascertain that the visual display would attract the child's attention.

*Goal detection task.* The procedure was based on Woodward (2003). The infant faced a small stage looking like a puppet-theatre on which there were two toys, a brown and white dog and a multicolored ball. An actor, wearing a long-sleeved red shirt, sat behind the stage with her face and upper body in clear view of the infant. Between trials, green curtains on each side of the stage were closed to hide the toys and actor from view. Each trial began with the curtains parting to reveal the two toys (28 cm apart from one another) and the actor. The actor made eye contact with the infant, said "Hi" and then

"Look" as she turned to gaze at one of the two toys. She stayed in this position until the end of the trial. If the infant did not make eye contact with the actor at the beginning of the trial, the actor repeated her greeting until the infant did so. Then, she said "Look" as she turned to gaze at one of the toys. The experimenter who was coding the infant's looking time was able to see the actor from behind, and thus began coding as soon as the actor had stopped moving and was in her final position (i.e., looking at the toy). The trial ended when the infant had looked away for two consecutive seconds or when 120 seconds had elapsed.

During the habituation trials, the actor always looked at the same toy. The habituation phase ended when the total looking time for three successive trials was less than 50% of the infant's total looking time during the first three habituation trials, or after a maximum of 14 trials. Once the infant had habituated, the computer program produced a "bing" sound that signaled the beginning of the test phase. The position of the toys behind the curtain was reversed before the test phase began. During the test phase, infants were presented with two types of test trials in alternation for a total of six trials. In the "new toy" test event, the actor turned to the same side as during habituation, thus gazing at a different toy than the one she had gazed at during habituation. In the "old toy" test event, she oriented to the other side of the stage and gazed at the same toy as during habituation, now located on the other side of the stage. As in the habituation phase, the actor made eye contact with the infant and said "Hi" and then said "Look" as she turned to gaze at one of the toys. Once again, test trials began when the actor had reached her final position and ended when the infant looked away for two consecutive seconds.

For half of the infants, the actor turned to the left side of the stage during the habituation phase, for the other half she turned to the right. For each direction, half of the infants saw the actor looking at the dog and half saw her looking at the ball. In addition, half of the infants began the test phase with a new toy trial and half began with an old toy trial.

*Action parsing task.* The procedure was based on Baldwin et al. (2001). Infants completed this task in two parts. Specifically, they were habituated to one movie and then shown the test trials that corresponded to that movie. Following the first movie, infants remained in their seat and parents played with them while the experimenter prepared the computer program to run the second movie (i.e., approximately 60 seconds elapsed between viewings). After this short break, infants were habituated to the second movie and then shown the test trials that corresponded to that movie. The experimental session began with the activation of the attention-getter to draw the infant's attention to the computer screen. As soon as the child looked at the screen, the experimenter pressed a key to stop the attention getter and begin presentation of the first movie. During the first habituation phase, infants watched consecutive trials of the unjunctured action sequence. Because this was an infant-controlled procedure, infants' looking time determined the length of each habituation trial. The 8 sec movie was looped repeatedly (up to 5 times) for a maximum trial length of 40 sec. Once infants had looked away for 2 consecutive seconds, or 40 sec had elapsed, the trial ended. Prior to the initiation of a new trial, infants were always oriented to the computer screen via the attention-getter. Infants' looking time was determined on-line by the experimenter who was coding visual fixation from the video monitor located behind the apparatus. The habituation phase ended when the total looking time during three successive trials was less than 50% of the infant's total looking time during the first three habituation trials, or after a maximum of 12 trials.

Once the infant had habituated, or had seen 12 habituation trials, the test phase began. Each infant saw 4 test trials: two "completed" test trials and two "interrupted" test trials. As in the habituation phase, infants were oriented toward the computer screen via the attention-getter at the start of each trial. The trial ended when they had looked away for 2 consecutive seconds or when the maximum trial length (48 sec) had elapsed. The order of the movies shown and the order of the test trials were counterbalanced across participants. Also, the order in which the 10-month-olds completed this task and the goal-detection task was counterbalanced.

*Selective action imitation task.* The procedure was adapted from Carpenter and her colleagues (1998) and is described in detail in Olineck and Poulin-Dubois (2005). After two warm-up trials designed to familiarize infants with the imitation task, infants were shown live demonstrations in which the investigator modeled a sequence of two actions, using the toy devices. One of the actions was portrayed as accidental and the other as intentional. While completing the accidental action, the investigator looked away from the box lid, and then put her had to her mouth, and said "Whoops". Her facial expression was also surprised and her upper body jumped up slightly. While completing the intentional action, the investigator leaned forward slightly, gazed at one of the specific devices, and completed the action slowly. She also smiled and said "There". After the experimenter demonstrated the action sequence, a computer animation was displayed. Then, infants were given a turn to manipulate the devices in order to activate the computer animation. If infants only reproduced the accidental action, the computer animation was not activated. Instead, the investigator proceeded to the next experimental trial. During the test phase, the order of the action sequence (i.e., accidental-intentional or intentional-accidental) alternated across the four trials. In addition, the side of the intentional action was counterbalanced, as well as the order in which the four experimental box lids were presented. Infants' responses during this task were video-taped for coding purposes.

*Behavioral re-enactment task.* The procedure was based on Meltzoff (1995) and Bellagamba et al. (2006). The testing session began with a warm-up phase in which the infant was presented with three colorful blocks to explore. Once the infant was comfortable with the experimenter and the testing room, the blocks were removed and the experimental trials commenced. Specifically, the infant was tested on the "Demonstration of Intention" condition of the re-enactment task (Meltzoff, 1995). For each of the test trials, the experimenter presented an object and said "I have something to show you. Watch me". Then, the experimenter modeled the intention to perform an act three times. For the dumbbell object, the experimenter held a wooden cube in each hand and appeared as though she was trying to pull the toy apart in two halves. However, she failed to do so because one of her hands slips off the cube as she pulled. While modeling this action three times, the actor's hand slips off alternating ends of the object (i.e., right side, left side). For the box with the embedded button, the experimenter attempted to use the wand to press the button but always missed (i.e., came down on the surface of the box instead). For each demonstration, the actor "missed" the button by hitting in a different location (i.e., too far right, left, and too high above the button). For the horizontal prong device, the experimenter picked up the loop but "accidentally" drops it as she approached the prong. During the three demonstrations, the loop was "accidentally' released in different locations (i.e., too far left, too far right, and just below the prong). For the cylinder and beads, the experimenter dropped the beads so that they just missed the cylinder and fell onto the table instead. During one demonstration, the beads were dangled so they connected with the edge of the cylinder but then fell to one side. On another demonstration, the beads were dropped too far in front of the cup. On the final demonstration, the beads were gathered in the experimenter's hand, scraped over the opening of the cylinder, and then dropped to the other side. For the plastic square and dowel, the experimenter attempted to put the square on the dowel but was unable to line it up properly. During these three demonstrations, the experimenter placed the square too far left, too far right, and then too far in front of the dowel. Importantly, the experimenter had no linguistic expressions or facial expressions regarding her failed attempts. Following the demonstration, the experimenter offered the object to the child and said "Now it's your turn". Infants were provided with a 20 sec response period before the next object was introduced. The order in which the object sets were presented was counterbalanced across participants. Following the "Demonstration of Intention" condition, infants completed a post-test, in which they were shown a demonstration of the target action and then given a turn to reproduce this action. The purpose of this post-test was to determine whether infants possessed the motor skills required to complete each target action. Infants were not provided feedback following their response and their behaviors during this task were video-taped for coding purposes.

*Coding and Reliability*

*Goal-detection task.* As previously described, infants' looking time during the testing session was coded live. As such, the primary experimenter coded the data for infants' looking time. A random selection of 20% of participants (n=5) was recoded by another experimenter for reliability purposes. Using Pearson product moment correlations, the mean inter-rater agreement for the infants' looking time was r=.99. As outlined by Woodward (2003), it was also critical to determine whether infants followed the actor's gaze during this task. On a second pass of the tapes, infants' looks to each of the two toys during the test trials were coded by the primary experimenter. The coder was not informed of the particular test condition being observed, and could not see the toys or the actor. A random selection of another 5 infants was recoded by a second experimenter. Using Pearson product moment correlations, the mean inter-rater agreement for the infants' looking time was r=.96.

*Action parsing task.* Infants' looking time during the testing session was also coded live. As such, the primary experimenter coded the data for infants' looking time. A random selection of 20% of participants (n=5) was recoded by another experimenter for reliability purposes. Using Pearson product moment correlations, the mean inter-rater agreement for the infants' looking time was r=.99.

*Selective action imitation task.* Each participant was videotaped and all tapes were coded by the primary investigator. The coding scheme for this experiment was modeled after the one used by Carpenter et al. (1998). Infants were coded as having manipulated a device (i.e., reproduced an action) if their attention was directed at the device and they were obviously attempting a manipulation. In the warm-up trials, infants' abilities to imitate actions were coded. All infants successfully reproduced the actions demonstrated in both warm-up trials. In the test phase, infants' actions on each device, and the order in which the actions occurred, were coded. If infants repeatedly manipulated one device (e.g., pushed button several times) it was coded as the same action. In the cases where infants manipulated both devices at the same time they were coded as completing the actions simultaneously. Infants who touched one device while actively manipulating the other device were coded as reproducing the action associated with the device occupying their attention. A sample of the document that was used for coding this task is included in Appendix E. In order to establish inter-rater reliability, 20% of the data (n=5) were coded by a second coder. There was 98% agreement between the two coders.

*Behavioral re-enactment task.* Each participant was videotaped and all tapes were coded by the primary investigator. The coding scheme was modeled after Meltzoff (1995) and Bellagamba et al. (2006). For each test trial, children were given 20 seconds to manipulate the object, beginning with his or her first touch of the object. The experimenter coded whether or not infants completed the target action during this response period. For the dumbbell, a "yes" was coded if the infant pulled the object apart. For the box, a "yes" was coded if the infant used the wooden wand to push the button. For the prong, a "yes" was coded if the infant hung the loop around the protruding prong. For the beads, a "yes" was coded if the infants placed the beads into the cylinder. Finally, for the plastic square, a "yes" was coded if the infant placed the square over the wooden dowel so that the dowel protruded from the hole. These criteria were used to code infants' responses during the "Demonstration of Intention" condition and the post-test that followed. A sample of the document that was used for coding this task is included in

Appendix F. To establish inter-rater reliability, 20% of the data (n=5) were coded by a second coder. There was 100% agreement between the two independent coders.

## Results

*Goal detection task.* Before examining whether infants were sensitive to goal-directed actions, it was important to confirm that infants had in fact habituated to the live demonstration provided during the habituation phase. Indeed, infants' average looking time on the last block of three familiarization trials ($M$=6.98, $SD$=2.48) was significantly less than their average looking time on the first block of three familiarization trials ($M$=17.15, $SD$=5.92), $t(21)$=11.72, $p$<.05. Next, planned contrasts were conducted to examine whether infants looked longer on the new toy test trials compared to the old toy test trials. Results indicated that infants' mean looking time for new toy trials ($M$=8.02, $SD$=3.42) was not significantly different from their mean looking time for old toy trials ($M$=7.61, $SD$=4.34), $t(21)$=.50, $p$>.05. However, when the looking times for only the first trial were compared, results indicated that infants looked significantly longer at the new toy trial ($M$=11.73, $SD$=6.34) compared to the old toy trial ($M$=8.04, $SD$=5.02), $t(21)$=-2.33, $p$<.05.

Importantly, analyses also confirmed that infants were following the actor's eye gaze during this task. The proportion of the trial spent looking at the object of the actor's gaze and the proportion of looking time at the other toy was calculated for each participant. Infants' mean proportion of time that they spent looking at the object of the actor's gaze ($M$=.28, $SD$=.13) was significantly higher than the proportion of time they spent looking at the other toy ($M$=.17, $SD$=.10), $t(19)$=3.27, $p$<.05.

*Action parsing task.* Preliminary analyses indicated that infants' looking times toward the two digitized videos (i.e., action sequences) were similar. Moreover, there was no significant interaction between action sequence and type of test video (i.e., completed video vs. interrupted video). As such, the data was collapsed across the two digitized videos in subsequent analyses.

Prior to examining whether infants detected disruptions in the structure of intentional action, it was important to confirm that infants had in fact habituated to the uninterrupted videos presented in the habituation phase. Indeed, infants' average looking times on the last block of three familiarization trials ($M$=10.37, $SD$=4.33) was significantly less than their average looking time on the first block of three familiarization trials ($M$=22.93, $SD$=10.40), paired $t(21)$=6.82, $p$<.05. Next, planned comparisons were conducted in order to determine whether infants demonstrated renewed interest in response to the test videos, relative to their looking time on the last habituation trial ($M$=5.77, $SD$=4.09). Interestingly, infants' looking time was significantly higher for the first interrupted video ($M$=7.71, $SD$=5.74), $t(21)$=1.65, one-tailed $p$=.05. Infants showed no such renewed interest in response to the first completed test video ($M$=5.77, $SD$=4.49), paired $t(21)$=.002, one-tailed $p$>.05. Infants' looking times on the two test videos were also compared. Overall, infants did not look significantly longer on the interrupted test videos ($M$=7.83, $SD$=5.07) compared to the completed test videos ($M$=7.24, $SD$=3.91), $t(21)$=0.52, $p$<.05. However, 15 of the 22 infants did look longer at the interrupted test videos than at the completed test videos, sign test, one-tailed $p$=.06. It is possible that infants became confused and/or less attentive due to the repetition of test events. To address this issue, infants' responses during the first trial were examined.

Analyses revealed that, when looking times for the first trial of each test video were isolated, infants looked longer at the interrupted test video (*M*=7.71, *SD*=5.74) than the completed test video (*M*=5.77, *SD*=4.49), $t(21)=1.78$, one-tailed $p<.05$.

*Selective action imitation task.* To calculate the percentage of intentional and accidental actions reproduced, the number of each type of actions reproduced (maximum score=4) was divided by the total number of times the action was modeled (i.e., 4 of each action type) and multiplied this number by 100. These data were submitted to a repeated measures analysis of variance with action type (i.e., intentional vs. accidental) as a within subjects factor. As expected, there was a significant effect of action type, $F(1, 19)=5.59$, $p<.05$. Overall, infants imitated significantly more intentional (*M*=92.50, *SD*=14.28) actions than accidental (*M*=80.00, *SD*=19.19) actions. In the next series of analyses, planned comparisons were conducted to more closely examine trials in which infants imitated only one action (range=0-3, *M*=1.1, *SD*=.97). Results indicated that the percentage of trials that infants reproduced only the intentional action (*M*=20.00, *SD*=19.19) was significantly greater than the percentage of trials they completed only the accidental action (*M*=7.75, *SD*=14.28), paired $t(19)=2.36$, $p<.05$. These results are consistent with results reported in previous studies. For example, Olineck and Poulin-Dubois (2005) found that infants reproduced 95.26% of intentional actions (out of times they were modeled) and 75.39% of accidental actions (out of times they were modeled).

*Behavioral re-enactment task.* Each infant was assigned a score ranging from 0 to 5 according to how many target actions they reproduced. The mean number of target actions reproduced was 1.45 (range= 0 to 4, median=1.00, *SD*=1.15). As such, infants' abilities to complete these actions (i.e., post event actions) were also taken into consideration. To calculate the percentage of target actions completed relative to the number of actions they were able to reproduce, the number of target actions infants completed during the test phase was divided by the total number of actions they were able to complete during the post test and this number was multiplied by 100. On average, infants completed 43.60% of the target actions they were able to re-enact (range=0 to 100, median=40.00, *SD*=29.28).

*Relationship between tasks*. In order to maximize the sample size and the statistical power, as well as increase variability, three infants who were previously excluded because they did not habituate during the visual attention tasks administered at 10 months were included in the following analyses. Thus, for correlations between tasks administered at 10 months, the sample included 25 infants. For correlations between tasks administered at 14 months, the sample included 20 infants. Finally, for correlations between 10- and 14-month-old tasks, the sample consisted of 19 infants (i.e., one of the infants tested at 14 months was not included in the final sample at 10 months).

To represent infants' performance on the goal-detection task, two dependent variables were utilized: (1) the difference between the infants' looking time during the first new toy trial and their looking time during the first old toy trial (i.e., Difference Score= looking time during the first new toy trial-looking time during the first old toy trial) (*M*=3.07, *SD*=7.95), (2) infants' weighted decrement of attention score (i.e., Weighted Decrement of Attention Score = (looking time for habituation trial 1 + looking time for habituation trial 2) – (looking time during 2$^{nd}$ to last habituation trial + looking time during last habituation trial) / (looking time for habituation trial 1 + looking time for habituation trial 2) (*M*=.56, *SD*=.33). Recent research has shown that infants' weighted decrement of attention score predicts their theory of mind abilities later on (Wellman et al., 2008; Wellman et al., 2004). To represent infants' performance on the action parsing task, two dependent variables were utilized: (1) the difference between infants' average looking time during the first interrupted test videos and their average looking time during the first completed test videos (i.e., Difference Score=mean looking time during the first interrupted test videos -mean looking time during the first completed test videos (i.e., collapsed across the two movies; *M*= -.10, *SD*= 10.58), (2) infants' weighted decrement of attention score (i.e., Weighted Decrement of Attention Score = (looking time for habituation trial 1 + looking time for habituation trial 2) – (looking time during 2$^{nd}$ to last habituation trial + looking time during last habituation trial) / (looking time for habituation trial 1 + looking time for habituation trial 2; *M*=.60, *SD*=.30). To represent infants' performance on the selective action imitation task, two dependent variables were utilized: 1) the difference between the percentage of time children reproduced the intentional action (out of 4) and the percentage of time they imitated the accidental action (out of 4) (i.e., Difference Score = % intentional actions imitated - % of accidental actions completed) (*M*=12.5, *SD*=23.65, range=-25-50), 2) the percentage of time they imitated the intentional action first (*M*=57.5, *SD*=20.03, range=25-100). These two dependent variables were selected because they have previously been used to represent infants' performance on the selective action imitation task in other studies (e.g., Olineck & Poulin-Dubois, 2007). To represent infants' performance on the behavioral re-enactment task, two dependent variables were utilized: (1) infants' total target score (*M*=1.45, *SD*=1.15), (2) the percentage of target actions completed out of the number of actions infants were able to complete (i.e., number of target action completed during test phase / number of target actions that the infant was able to complete taking post test into account, multiplied by 100; $M$=43.6, $SD$=29.28, range = 0 to 100). Finally, to represent infants' receptive language skills, the total number of words the infant understood ($M$=33.45, $SD$=19.44, range = 8 to 83) was utilized. To examine whether there was a link between infants' performance on these intention tasks and/or their receptive language skills, Pearson correlations were computed between all dependent variables. These correlations are presented in Table 1.

The first question of interest was whether infants' performance on the two visual attention tasks administered at 10 months was related. Indeed, results indicated that infants' weighted decrement of attention score during the habituation phase of the goal detection task was positively correlated with the same variable on the action parsing task, $r$=.38, $p$<.05, one-tailed. No significant correlations emerged between the difference scores obtained by infants on these tasks.

The second question of interest was whether infants' concurrent performance on the two imitation tasks administered at 14 months would also be linked. Contrary to the hypotheses, there was no statistically significant relation between infants' concurrent performance on the two imitation tasks completed at 14 months. However, the correlation between the percentage of time infants completed the intentional action first (selective action imitation task) and the number of target actions they completed relative to the number of actions they were able to complete (i.e., taking their performance on the post test into account; behavioral re-enactment task) approached statistical significance (i.e., $r$=.34, $p$=.07, one-tailed).

Table 1

*Intercorrelations between receptive vocabulary and performances on visual attention and imitation tasks*

| | MCDI | GD-D | GD-DA | AP-D | AP-DA | SI-D | SI-IF | BT-T | BT-P |
|---|---|---|---|---|---|---|---|---|---|
| Language: Number of words infant understands (MCDI) | 1.00 | -.00 | .13 | .21 | .05 | -.07 | -.23 | -.11 | .23 |
| Goal detection: First Trial Difference score (GD-D) | | 1.00 | -.18 | -.00 | -.14 | .24 | .29 | .15 | .20 |
| Goal detection: Decrement of attention score (GD-DA) | | | 1.00 | .01 | .38* | -.24 | -.12 | .45* | .45* |
| Action parsing: First Trial Difference score (AP-D) | | | | 1.00 | -.06 | -.19 | -.10 | -.04 | .06 |
| Action parsing: Decrement of attention score (AP-DA) | | | | | 1.00 | -.26 | -.33 | .43* | .33 |
| Selective action imitation: Difference score (SI-D) | | | | | | 1.00 | .63** | -.17 | .15 |
| Selective action imitation: % intentional actions first (SI-IF) | | | | | | | 1.00 | .02 | .34 |
| Behavioral-re-enactment: Total target score (BT-T) | | | | | | | | 1.00 | .67** |
| Behavioral-reenactment: % target actions relative to ability (BT-P) | | | | | | | | | 1.00 |

* $p<.05$, one-tailed; ** $p<.01$, one-tailed

The third question of interest was whether infants' performance on the two tasks administered at 10 months predicted their performance on the two imitation tasks administered approximately four months later. Interestingly a significant relationship was found between infants' performance on the goal-detection task at 10 months and their subsequent performance on one of the imitation tasks administered at 14 months. Specifically, infants who obtained larger decrement of attention scores during the goal detection task also completed significantly more target actions during the behavioral re-enactment task, $r=.45$, $p<.05$. A consistent positive correlation emerged between infants' decrement of attention scores during the goal detection task and the percentage of target actions they completed during the behavioral re-enactment task, relative to the number of actions they were able to complete (i.e., taking performance during post test into account), $r=.45$, $p<.05$.

Infants' performance on the action parsing task administered at 10 months was also linked to their performance on one of the two imitation tasks administered at 14 months. Specifically, infants' decrement of attention score during the action parsing task predicted the number of target actions they completed during the behavioral re-enactment task, $r=.43$, $p<.05$. No significant correlations were found between infants' performance on the action parsing and selective action imitation tasks.

The final question of interest was whether infants' performance on any of these nonverbal tasks were associated with their receptive language abilities at 14 months, as measured by their comprehension score on the MCDI. No significant correlations emerged.

## Discussion

To investigate infants' understanding of goals and intentional actions, researchers have employed a number of different methodologies.-Some have used measures of habituation-dishabituation to demonstrate that infants are sensitive to goal-directed actions such as gestures or gaze (e.g., Woodward, 1998, 2003). Other studies examining infants' understanding of intention have used imitation paradigms (e.g., Carpenter, Akhtar et al., 1998; Meltzoff, 1995). Converging evidence from across the field of cognitive development has revealed that infants as young as 6 months are adept at detecting goals in others' actions with visual attention paradigms and as early as 14 months with imitation paradigms. Currently, there is a broad consensus that infants can represent other people's actions in ways that are important for intentional understanding; however, there is no evidence that the same underlying skills are involved. In the present study, we sought to test whether the abilities assessed with these tasks are interrelated by using a within-subject design.

The first contribution of the present study is the replication and extension of previous findings. Specifically, our data from the action parsing task confirmed that 10-month-old infants possess skills for parsing continuous human action according to the initiation and completion of intentional actions (e.g., Baldwin et al., 2001; Saylor et al., 2007). This replication is important because we presented infants with movies depicting an actor completing action sequences that were more novel than the "kitchen clean up activities" (e.g., reaching to grasp a towel and picking up an ice cream container) used by Baldwin et al. (2001). In discussing the interpretation of their findings, Baldwin and her colleagues (2001) argued that because the kitchen scenes were probably familiar to infants in a general sense, comparable parsing success with objects and actions that were more novel needed to be demonstrated. Although the action sequences used in the present study (i.e., pushing a car down a ramp and dropping objects inside a container) are also somewhat familiar gestures for infants, the contexts that we designed for these actions was probably more novel. Recently, Saylor et al. (2007) showed infants live displays involving actors engaged in novel action sequences that were comparable to ours (i.e., opening a drawer, putting a sock inside a drawer). Once again, their results confirmed that 10-month-old infants segment continuous human action along intentional boundaries.

We also replicated and extended previous findings in the second task administered to 10-month-olds. In her seminal paper, Woodward (2003) demonstrated that 12-month-olds, but not 7- and 9-month-olds, represent gaze in terms of the relation between the person and the object of his or her gaze. Our data indicate that this ability has developed by 10 months of age, although it is still fragile reflected in the fact that the effect was only observed on the first pair of test trials.

With regard to the imitation tasks administered at 14 months, the present data are in accord with previous research reporting that children as young as 14 months can distinguish between intentional and accidental actions, even if this ability becomes more robust with age (Carpenter, Akhtar et al., 1998; D'Entremont & Yazbek, 2006; Olineck & Poulin-Dubois, 2005). It is noteworthy that infants in the present study tended to reproduce a large number of both intentional (92.50%) and accidental actions (80.00%). This may be interpreted by some as evidence to suggest that 14-month-olds are less likely to make a distinction between intentional and accidental actions. However, we would argue that these high response rates are indicative of the attractiveness of the stimuli and infants' impulsivity at this age. Similar response rates have been cited in previous research. For example, Olineck and Poulin-Dubois (2005) found that infants' ranging from 14 to 18 months of age reproduced 95.26% of the intentional actions and 75.39% of the accidental actions that were modeled. Despite their tendency to reproduce both action types at high rates, infants' ability to distinguish intentional actions is reflected in their difference scores, their inclination to reproduce intentional actions first, and their tendency to reproduce only intentional actions (i.e., during trials where one action is reproduced). Together with previous research, the present study suggests that 14-month-olds differentiate intentional from accidental action. It has been argued that infants' understanding of accidental actions is particularly important when assessing infants' understanding of others' intentions, because they involve the understanding that others may have intentions that may not match with the current state of affairs. This level of understanding is more advanced than the simple understanding that people may have intentions that differ from one's own.

Another contribution of the present study was the administration of the demonstration of intention condition of the behavioral re-enactment task to 14-month-old infants (Meltzoff, 1995). Our sample of children performed more poorly than expected on this task. For example, in a recent longitudinal study, 12-month-olds produced the target action 26% of the time and 15-month-olds produced the target action 63% of the time in the same Demonstration of Intention condition (Bellagamba et al., 2006). With a stuffed orangutan as a model, Johnson et al. (2001) observed that 15-month-olds produced the target action 37% of the time. In comparison, the 14-month-olds in the present study performed the target action on only 29% of the trials. However, when infants' ability to complete the actions (i.e., performance on the post test) was taken into account, the success rate was comparable to other studies (i.e., infants' completed an average of 43.60% of target actions). As such, it seems like the actions that were modeled were difficult for our sample of children to perform. Nevertheless, it is important to note that there was significant variability in infants' performance on this task and that their performance on this task was found to be related with their performances on other tasks designed to measure intention understanding at 10 months. Beyond the replication and extension of previous work, the most important goal of the present study was to examine infants' understanding of intentional action across different measures. Given that independent data sets have revealed that 10- to 14-month-old infants have some understanding of intentional action, it was expected that there would be a relationship in infants' performance across these tasks, similar to the one reported in theory of mind tasks included in experiments on representational change with preschoolers (Gopnik & Astington, 1988). To our knowledge, the present study is the first to employ a within-subjects design to explore infants' understanding of intentional action using a number of different tasks designed to tap the same construct.

Importantly, we found a number of interesting links between infants' performance on the different tasks used to measure understanding of intentional action. For instance, we uncovered a significant link between-infants' weighted decrement of attention scores during the goal detection task and their subsequent performance on the behavioral re-enactment task. The fact that a significant link was uncovered using infants' decrement of attention score is consistent with other recent longitudinal studies which have shown that measures of infant social attention (i.e., decrement of attention during habituation to displays of intentional action) are predictive of later theory of mind abilities (e.g., Aschersleben et al., in press; Wellman et al., 2008; Wellman et al., 2004). According to Wellman and his colleagues (2008), infants' attention during habituation is an informative measure because it reflects infants' ability to parse displays meaningfully during their initial exposure to them.

Results from the present study also demonstrated that the weighted decrement of attention score that infants obtained during the action parsing task was related to their subsequent performance on the behavioral re-enactment task. We believe that this is a very exciting finding as both tasks involve incomplete intentional actions, suggesting that attention to the structure of intentional action may be a precursor to the ability to anticipate the intention behind a failed attempt. In a way, these findings provide indirect support for the hypothesis that the failed attempt task measures intention understanding at a behavioral level (intention-in-action) as opposed to a more abstract level (intention-in-the-mind; (Meltzoff, 1995).

As expected, there were also positive associations between infants' concurrent performance on the two visual attention tasks administered at 10 months. Specifically, infants' decrement of attention scores on the goal detection and action parsing tasks were positively correlated. This finding suggests that infants' information processing during the habituation phase was similar for both tasks. This significant correlation is impressive, given that a live event was presented in the goal-detection task, whereas movies were shown in the action parsing task. No such link was found between infants' sensitivity to the boundaries of intentional action (i.e., difference score during action parsing task) and their ability to detect other people's goals (i.e., difference score during the goal detection task).

A surprising result of the present investigation was that 14-month-olds' concurrent performances on the two imitation tasks were unrelated. It is possible that the selective action imitation and behavioral re-enactment tasks are tapping into different social cognitive abilities. The hypothesis that these tasks may tap into different skills is empirically supported by the fact that children with autism are able to complete the failed attempt task (Aldridge, Stone, Sweeny, & Bower, 2000; Carpenter, Pennington, & Rogers, 2001) but not the selective action imitation task (D'Entremont & Yazbek, 2006). During the selective action imitation task, infants were shown demonstrations that included vocalizations (i.e., "whoops" vs. "there"), facial expressions (i.e., surprise vs. contentment), different eye gaze patterns (i.e., looked away from device while performing accidental action, looked intently at device while performing intentional action), and different body posturing (e.g., body jumped slightly during the completion of accidental action). In contrast, the demonstrations provided during the behavioral re-enactment task did not include linguistic or facial expressions. Perhaps infants' performance on the selective action imitation task reflects their sensitivity to social-communicative cues. According to Tomasello et al. (2005), understanding intention involves understanding goal directed action and observable outcomes, as well as recognizing emotional reactions and other non-verbal behavior. Further research is needed to explore whether infants' performance on the selective action imitation task may be linked with their performance on other intention tasks that include social-communicative cues. Nevertheless, research has shown that infants' performance on the selective imitation task predicts their later use of internal state terms, as well as their performance on a preschool intention task (Olineck & Poulin-Dubois, 2005, 2007). These studies suggest that this imitation task is tapping into an understanding of intention that may be a precursor to later theory of mind.

Importantly, results from the present study provide preliminary evidence to suggest that the action parsing and goal detection tasks may tap into the same ability to analyze intentional action as the behavioral re-enactment task. Interestingly, recent research has demonstrated that infants' performance on the behavioral re-enactment task at 12-15 months of age predicted their subsequent performance on tasks measuring perception and intention understanding at 39 months (Colonnesi, Rieffe, Koops, & Perucchini, in press). More research is needed to determine whether infants' performance on the failed-attempts task would also predict their later use of internal state language and their more general theory of mind skills (e.g., Theory of Mind Scale: Wellman & Liu, 2004) in the preschool period.

It is our belief that longitudinal investigations, using within subjects designs, represent an important new approach to study early social cognition development. Being able to understand others' intentions has been proposed as one of the first steps in the development of a theory of mind (Tomasello et al., 2005). Although, there are many studies reporting some form of goal or intention understanding in infancy, it is unknown whether these experimental procedures tap into the same underlying skills. The present study was the first in the field to explore this key issue. Our preliminary results suggest that there are empirical relationships between the visual attention and imitation measures currently being used to measure infants' early intentional understanding. It is possible that these links reflect infants' developing understanding of intentional action. However, it is also possible that these links may be due to other determinants of task performance such as general intelligence, information processing speed, memory and/or executive function skills. Recent research has addressed this issue by including a variety of control tasks. For example, Yamaguchi, Kuhlmeier, Wynn, and vanMarle(in press) administered the Theory of Mind Scale (Wellman & Liu, 2004) to preschoolers who had previously participated in either a social attention task examining infants' ability to interpret goal directed action or a nonsocial attention task that measured infants' ability to discriminate temporal durations of sounds. They found that infants' looking time patterns in the infant social attention task, but not the nonsocial attention task, were linked with preschool theory of mind. These findings are important because they indicate that the developmental continuity in social cognition that was demonstrated from infancy to preschool was not simply due to general attentional or cognitive capacities that would have also affected performance on the nonsocial infant attention task. More longitudinal studies, with larger samples and a variety of control tasks, are essential to determine whether there is continuity in children's understanding of intentional action and whether the tasks currently being used to measure infants' implicit understanding of intention are tapping into the same underlying socio-cognitive abilities.

Chapter 3

# Imitation of Intentional Actions and Internal State Language in Infancy Predict Preschool Theory of Mind Skills

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## Contribution of Authors

This section documents the contributions made by the first author to the article titled "Imitation of intentional actions and internal state language in infancy predict preschool theory of mind skills". This research was conducted in the Cognitive Development Laboratory in the Centre for Research on Human Development at Concordia University, Montreal.

This study was designed by both authors collaboratively. Two research students, who were jointly supervised by the first and second authors, were also involved. In terms of the experimental set up, both authors worked with a carpenter to devise an apparatus used during one of the experimental tasks. The first author co-supervised the research students as they gathered additional stimuli, devised administration orders (i.e., counterbalancing), and drafted recruitment letters and consent forms. The first author created detailed scripts to be followed verbatim during testing, as well as coding sheets to be used during data collection.

The initial infant study was part of the first author's Masters Thesis, which was also supervised by the second author. In terms of data collection for the follow-up experiments, the two research students recruited and tested approximately half of the participants (i.e., those children who were initially tested at 14 months). These testing sessions were frequently observed by the first author. The remaining participants (i.e., those initially tested at 18 months of age) were recruited and tested by the first author and a research assistant. With English-speaking families, the first author explained experimental procedures to parents and ran the experimental procedure. With French-speaking participants, a research assistant explained procedures to parents and completed experimental tasks with children. The first author was involved in testing these children at a more peripheral level (e.g., unseen actor manipulating experimental stimuli during one of the preschool tasks). The first author watched the recording of every testing session in order to code children's behavior during the tasks. The first author entered the data into an SPSS worksheet and conducted the analyses. A research assistant, who was not informed of the study hypotheses, re-coded the data for reliability purposes and re-entered the data to ensure its accuracy. The first author wrote letters to parents describing the research findings and thanking them for their participation.

The first author wrote the abstract, introduction, methods, and results sections of this paper, with the second author offering comments and revisions. Both authors collaborated in writing the discussion section. This paper was published in the *European Journal of Developmental Psychology, 4*, 14-30.

Abstract

The present study examined whether infants' imitation of intentional actions, concurrent vocabulary, and later internal state lexicon was related to their "theory of mind" (ToM) at preschool age. Initially, 14- and 18-month-olds completed an imitation task on intentional action understanding. Concurrent general vocabulary and internal state language at 32 months was also assessed. At approximately four years of age, children were re-tested with an interactive game measuring intention understanding, a false-belief task or the Theory of Mind Scale (Wellman & Liu, 2004), and the Peabody Picture Vocabulary Test. Infants' performance on the imitation task was related to their later concept of intention. Furthermore, internal state language was significantly correlated with later ToM. These findings suggest that there is developmental continuity between precursors to ToM in infancy and ToM in the preschool years.

Imitation of intentional actions and internal state language in infancy predict preschool theory of mind skills

Adults are constantly making inferences about the mental states underlying human behavior, a process that is called "theory of mind" (ToM). We see people as having mental states, such as beliefs about the world and desires for objects, and we understand their behavior based on this knowledge. Research has demonstrated that by the time children reach 4 or 5 years of age, they have a similar understanding of people as psychological beings (Wellman et al., 2001). However, much less is known about the putative precursors of ToM in infancy. A common criticism of experiments investigating the origins of ToM in infancy is that it is unclear whether the tasks that have been designed to tap into infants' early concept of the mind are actually measuring what they are intended to measure. For instance, some researchers have argued that infants' ability to predict how a person will act could be based simply on learned rules about behavior rather than on a conception that the mind mediates behavior (Perner & Ruffman, 2005). One way of establishing the external validity of these tasks is to determine whether there is continuity between children's early social-cognitive abilities and their later, more advanced, ToM skills. To date, there are very few longitudinal studies that have addressed this important gap in the literature. Therefore, the main goal of the present investigation was to systematically examine the continuity between children's performance on ToM tasks in infancy and the preschool period.

An active line of work has focused on infants' understanding of intentionality as the first step in developing a full-fledged ToM. Intention can be used to denote deliberate action as opposed to accidental action and to refer to the reason why something is done

(Astington, 2001). By the end of the first year, infants are learning to identify the intentions underlying other people's behavior. Specifically, they are sensitive to goal-directed actions and can detect the goals of other people using cues such as eye gaze, reaching, and emotional expressions (Baird & Baldwin, 2001; Phillips et al., 2002; Woodward, 1998, 2003). During the second year of life, research has indicated that infants display a more advanced understanding of intention (e.g., Bellagamba & Tomasello, 1999; Meltzoff, 1995). For instance, in an investigation that aimed to uncover infants' implicit understanding of intention, Carpenter, Akhtar, and Tomasello (1998) modeled intentional and accidental actions to infants ranging from 14 to 18 months of age and measured whether they preferred to imitate those actions that were completed intentionally. Overall, they found that, regardless of age, infants reproduced significantly more intentional than accidental actions. However, the limited number of infants at either end of their age range might have prevented them from detecting a developmental progression in infants' conception of intention. In order to more systematically investigate this issue, Olineck and Poulin-Dubois (2005) recently replicated and extended these findings by testing separate groups of 14- and 18-month-old infants. Importantly, the results revealed a developmental progression in infants' ability to differentiate intentional from accidental actions between 14 and 18 months of age. Taken together, these empirical studies suggest that infants understand intentional actions early on.

Additional evidence for an implicit understanding of intention and other mental states has been documented in children's early use of internal state terms during their everyday conversations (Bartsch & Wellman, 1995; Bretherton & Beeghly, 1982; Shatz et al., 1983). For instance, in a longitudinal study of 10 children who were followed from

1 to 6 years of age, Bartsch and Wellman (1995) found that children's conversations about the mind begin early with talk about desires and intentions (e.g., want, wish). Recently, an active line of research in ToM development has been focusing on the role that language might play in bringing the child from an implicit to an explicit understanding of the mind. Although there is no consensus about what aspect of language is involved in ToM development, it is well established that linguistic ability predicts performance on tests of theory of mind (Astington & Baird, 2005). For instance, it has been shown that individuals suffering from language deficits also tend to display delayed ToM development (Baron-Cohen, Baldwin, & Crowson, 1997; Bloom, 2000; Garfield, Peterson, & Perry, 2001; Tager-Flusberg, 1992). In addition, longitudinal research on language and ToM indicates that individual differences in language competence explain later individual variability in ToM skill between the ages of 2 and 3 years (e.g., Astington & Jenkins, 1999; Brown, Donelan-McCall, & Dunn, 1996; Ruffman, Slade, & Crowe, 2002; Watson, Painter, & Bornstein, 2002). Taken together, these and other investigations provide empirical evidence to suggest that language is an important antecedent to ToM development.

What remains to be investigated is whether there is continuity between children's implicit ToM in infancy, their use of internal state terms, and their explicit concept of people as mentalists in the preschool period. Many theoretical accounts propose that infants' social-cognitive abilities are related to later ToM ability. For example, it has been suggested that the emergence of joint attention skills in the second year of life is evidence for infants' understanding of intentional behavior (Baron-Cohen, 1995; Camaioni, 1992, 1997; Tomasello, 1995). Other researchers have proposed that imitation, which reflects the understanding of a match between oneself and the other, is the bedrock of ToM development (Meltzoff & Gopnik, 1993; Rogers & Pennington, 1991). Finally, pretend play has been proposed as an early manifestation of children's capacity for meta-representation (Leslie, 1987, 1994).

Despite much theorizing about the continuity of ToM in infancy and the preschool years, there is surprisingly little direct empirical evidence to support the theoretical positions just reviewed. In fact, only a handful of longitudinal studies have investigated the hypothesis of a developmental continuity in ToM development from infancy to childhood. In one of the first studies, Youngblade and Dunn (1995) investigated whether there were links between infants' pretend play with peers at 33 months of age and their ability to understand other people's feelings and pass standard false-belief tasks at 40 months of age. Importantly, they found that children who engaged in more pretend play when they were 33 months old were better at identifying feelings and recognizing false-beliefs 7 months later. Another longitudinal study examining the continuity of ToM skills was conducted by Charman, Baron-Cohen, Swettenham, Baird, Cox, and Drew (2000). These researchers initially measured 20-month-old play, joint attention, and imitation skills. Then, when these children were 44 months of age, they completed a battery of ToM tasks, including a standard false-belief measure. Interestingly, joint attention behaviors, but not imitation or play, were associated with ToM ability at 44 months. More recently, Wellman, Phillips, Dunphy-Lelii and Lalonde (2004) found that there was continuity between infants' understanding of goal-directed actions at 14 months, as measured with an infant-controlled habituation procedure, and their general concept of the mind at 4 years of age. Most recently, Olineck and Poulin-Dubois (2005) conducted the first longitudinal study to examine the link between infants' ability to distinguish intentional and accidental actions and their later production of internal state language. Fourteen- and 18-month-olds were administered an imitation task (adapted from Carpenter, Akhtar et al., 1998) in which an experimenter modeled accidental and intentional actions using toy devices. Then, when these children reached 32 months, their parents completed a 78-item questionnaire on their children's internal state language production, which was based on Bretherton and Beeghly (1982). The main findings revealed that infants who were more likely to only imitate an intentional action had a larger internal state lexicon at 32 months. Taken together, these results and those of the other few studies conducted recently are consistent with the hypothesis of continuity between early social-cognitive skills and later ToM. However, the specificity of the link between implicit and explicit ToM skills, as well as the factors that can account for this important developmental transition, remain to be examined.

The goal of the present study was to systematically investigate the relationship between children's understanding of intention-in-action and general language skills in infancy, internal state language in toddlerhood, and ToM in the preschool period. Another objective of the present study was to examine children's concept of intention from infancy through the preschool years. Intention understanding is particularly central to social competence because understanding others' intentions is necessary in many interactive contexts (Tomasello et al., 2005). We also investigated to what extent general verbal skills and mental state vocabulary in infancy can predict general ToM development years later. In the present experiment, children who originally participated in an imitation task when they were 14 or 18 months old and whose parents provided information regarding their internal state language at 32 months were invited to return to the laboratory when they were approximately 50 months of age. During this second laboratory visit, participants completed three tasks: 1) a target-hitting game adapted from Phillips, Baron-Cohen, and Rutter (Phillips, Baron-Cohen, & Rutter, 1998) which was designed to measure preschool children's ability to answer questions about their own intentions, 2) a standard "unexpected contents" false-belief task or the Theory of Mind Scale (Wellman & Liu, 2004), and 3) the Peabody Picture Vocabulary Test (PPVT: Dunn & Dunn, 1997) which measures receptive vocabulary by asking children to point to a picture that corresponds with a word. We expected that there would be a significant relationship between children's implicit concept of intention measured during infancy and their more explicit understanding of intention during the preschool years. In addition, we hypothesized that children's performance on the action imitation task at 14-18 months would be related to their later concept of the mind, as measured by the false-belief task and the Theory of Mind Scale. Finally, we predicted that there would be continuity between children's general language skills between 14 and 18 months, their use of internal state at 32 months of age, and their performance on preschool ToM tasks at 50 months of age.

## Method

### *Participants*

Twenty-six 14-month-olds and 30 18-month-olds participated in an action imitation task and their parents completed the MacArthur Short Form Vocabulary Checklist: Level II Form A (MCDI: Fenson et al., 2000). Approximately three years later, 15 of the children initially tested at 14 months and 16 of the children initially tested at 18 months returned to the laboratory to participate in the present follow-up experiment (20 females and 11 males; M=50.05 months, SD=4.37, range=45.26-55.43 months). A sample recruitment letter and consent form is included in Appendix G and H, respectively. Parents of 26 of these children also completed a questionnaire regarding their internal state language production (see Appendix I) at 32 months of age ($M$=31.99, $SD$=0.43, range=31.03-33.13 months).

*Materials*

*Imitation task.* A rectangular wooden box (38 cm long, 25 cm wide, 9 cm tall) with six removable lids was constructed. Embedded in the center of each of the box lids were toy devices that could be easily manipulated by the infant (e.g., handle that twists). Two of the box lids were always used in the warm-up phase of testing and the remaining four lids were randomly assigned to four experimental trials. One of the lids used in the warm-up phase of testing included one toy device and the remaining five box lids included two toy devices that were matched for size and level of attractiveness. The base of the box was visibly connected to a computer monitor via a telephone cord. Following the action demonstration, computer animations were surreptitiously activated by the experimenter and were displayed on the monitor.

*Target-hitting game.* A wooden structure (approximately 10 cm wide and 40 cm high), which shelved 6 different colored plastic canisters, was constructed. These plastic containers (7 cm wide and 7 cm tall) served as the targets for the game. They were easy to open and had the capacity to hold small prizes (e.g., ball, stickers). Half of the canisters contained a prize and half of them were empty. The plastic canisters were placed on a platform that consisted of six holes large enough to allow them to drop through when activated. The cans rested on small metal rods that were retracted electronically with a universal remote control (i.e., magic wand). Children were told that the objective of the game was to hit the cans off the wall by aiming the "magic wand" at a predetermined target. Indeed, the manipulation of the remote appeared to cause the can that was hit to fall from the wall directly. However, a hidden experimenter specified which canister fell off the shelf using a hand-held toggle switch with six positions corresponding to the six locations on the shelf. Therefore, the participant was in control of when the canister fell, but the hidden experimenter determined which canister fell. A flipbook representing the target color for each trial served as a visual reminder of the canister the child was intending to hit for each trial.

*False-belief task.* The props used in this task included a female puppet, an empty Smarties box, and 4 crayons.

*Theory of Mind Scale.* Brief vignettes adapted from Wellman and Liu (2004) were used, as well as toy figurines, puppets, pictures, and a Smarties box containing crayons. Children's responses during this and the above tasks were videotaped for coding purposes.

*Peabody Picture Vocabulary Test (Dunn & Dunn, 1997).* In order to administer this standardized language measure, the following were used: the test manual, the test book containing a series of pictures, and the standard response forms.

*Procedure and Design*

*Imitation task.* The procedure was adapted from Carpenter and her colleagues (1998) and is described in detail in Olineck and Poulin-Dubois (2005). After two warm-up trials designed to familiarize infants with the imitation task, infants were shown demonstrations in which the investigator modeled a sequence of two actions, using the toy devices. One of the actions was portrayed as accidental and the other as intentional. The accidental action consisted of the investigator looking away from the box lid, while completing the action, and then putting a hand to her mouth and saying "Whoops!" with suitable intonation. Additionally, during the "accident" the investigator's face registered surprise and her upper body jumped up slightly. The intentional action consisted of the investigator looking attentively at one of the specific devices, completing the action slowly, and then smiling and saying "There" with appropriate intonation. During the completion of the intentional action, the investigator also leaned slightly toward the devices. The action sequence demonstrated by the investigator always resulted in activating a computer animation display. Then, the infants were given the opportunity to activate the computer animation. It was activated approximately two seconds after infants reproduced the intentional action. This delay provided infants with the opportunity to also reproduce the accidental action. The computer animation was not activated in cases where infants only reproduced the accidental action. If infants failed to activate the end result, the investigator proceeded to the next experimental trial. During the test phase, the order of the action sequence (i.e., accidental-intentional or intentional-accidental) alternated across the four trials. In addition, the side of the intentional action was counterbalanced, as well as the order in which the four experimental box lids were presented.

*Target-hitting game.* The procedure for this task was modeled after Phillips et al. (1998). Children were told that the objective of the game was to use a magic wand to hit the canisters on the wall and win some prizes. They were informed that some of the cans contained a prize and some of them were empty. Following a brief demonstration by the experimenter, a warm-up phase consisting of two trials was administered. In both warm-up trials, the child always hit the target can; however, they only won one prize. During the test phase, the same procedure was employed. After the child hit a can and removed the lid to see if they won a prize, the experimenter responded with either "Oh look, you won a prize!" or "Oh look, no prize this time". The child was asked to hold the open canister (which either contained or did not contain a prize depending on the trial) in their hands while the experimenter said, "Listen carefully. Which can did you try to hit? The [insert color] or the [insert color]?" For half the trials, the color that was mentioned first was the target and the color mentioned second was one of the cans directly beside the target. For the remaining trials, the target color was mentioned second.

The task consisted of a combination of hit (H), miss (M), prize (P), and no prize (NP) outcomes. A hit was achieved when the target can fell off the wall and a miss occurred when the can beside the target fell down instead. Regardless of whether the trial was set up to be a hit or a miss, a can always fell off the wall. In order to isolate intention understanding from the desire to win a prize, there were two discrepant conditions in which the child either missed the target but won a prize (MP) or hit the intended can but did not win a prize (HNP). There were also two consistent conditions which could be answered based on desire and/or intention understanding: trials in which a prize was awarded when the target was hit (HP) or not awarded when a miss occurred (MNP). A total of 16 trials were administered, with 4 trials per condition. The condition (i.e., hit and miss) and outcome (i.e., prize and no prize) of the trials were counterbalanced. In addition, the order was arranged in a quasi-random fashion so that no outcome (i.e., prize vs. no prize), condition (i.e., hit vs. miss), or target color appeared more than twice in a row. Children's responses to the test question were recorded and the number of times they correctly identified the intended target was coded (maximum=16; see Appendix J for a sample coding document).

*False-belief task.* Children were shown a Smarties box and asked what they thought the box contained. If they did not spontaneously respond "candies" or "chocolates", the experimenter prompted them by pointing to the pictures on the box. After they responded correctly, the experimenter opened the box and revealed that there were really crayons inside. Then the experimenter put the crayons back inside the box, and asked the child what was really inside the Smarties box. Next, the experimenter introduced a puppet and asked children what Dora thought was in the box and whether she saw inside the box. Children were coded as having passed the false-belief task if they told the experimenter that Dora thought there were Smarties in the box and that she had not seen inside the box.

*Theory of Mind Scale.* Children were presented with five interactive stories (see Wellman & Liu, 2004 for detailed descriptions), using toy figurines, pictures, and/or puppets, and were then asked questions regarding their own mental states and those of the story characters (see Appendix K). The stories tapped into children's knowledge of other people's desires, beliefs, knowledge access, false-beliefs, and the contrast between real and apparent emotions. The experimenter coded whether children responded correctly to the questions measuring their understanding of the five mental states, and assigned children a total score (maximum =5) on the Theory of Mind Scale (see Appendix L). The criteria provided by Wellman and Liu (2004) were utilized when evaluating children's responses to the test questions. In addition to their overall score on the scale, children's performance on the false-belief task (i.e., pass or fail) was coded separately. Wellman and Liu (2004) consistently presented the story about diverse desires in the first or second position and the story regarding real and apparent emotions in the fourth or fifth positions. In the present experiment, the diverse desires task was always presented first and the real-apparent emotion task was always presented last. The remaining stories were presented in counterbalanced order, which results in a total of six orders for the tasks comprising the Theory of Mind Scale.

*Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1997).* The standardized protocol was used. Children's responses were recorded during the administration of the test, and they were assigned a standard score.

The children initially tested at 14 months completed the target-shooting game, the PPVT, and the false-belief task. When the 18-month-olds returned to the lab, we had access to the Theory of Mind Scale (Wellman & Liu, 2004) and therefore these children completed this measure, which includes the false belief task. All children completed the target-shooting game first; however the order of the PPVT and the false-belief task/Theory of Mind Scale were counterbalanced across participants.

*Reliability*

Each participant was videotaped while they completed the target-shooting game and the false-belief task or the Theory of Mind Scale. All tapes were coded by the primary investigator. In order to establish inter-rater reliability, 20% of the data (*n*= 6) was coded by a second coder. There was 100% agreement between the coders across the three tasks.

## Results

The first question of interest was whether there was continuity between children's performance on the action imitation task at 14-18 months and their performance on the target-shooting game at 50 months. To represent children's performance on the imitation task in infancy, we utilized two dependent variables: 1) the difference between the percentage of time children reproduced the intentional action (out of 4) and the percentage of time they imitated the accidental action (out of 4) (i.e., Difference Score = % intentional actions imitated - % of accidental actions completed) ($M$=25.81, $SD$=21.87, range=0-50), 2) the percentage of time they imitated the intentional action first ($M$=55.65, $SD$=25.58, range=0-100). The performance of the children included in the present longitudinal sample (N =31) was comparable to that of those who did not participate (N = 25) for each of these two variables. To represent children's performance on the target-shooting game, two dependent variables were also used. We computed children's scores in each of the discrepant conditions: 1) when children hit the target but did not win a prize (HNP: $M$=3.68, $SD$=.87, range=0-4), and 2) when children missed the target but won a prize (MP: $M$=1.35, $SD$=1.52, range=0-4). We analyzed children's performance in these two specific conditions because their intention (i.e., to hit a predetermined target) was distinct from their desire (i.e., to win a prize). In the original study by Phillips et al. (1998), children's performance on trials where the mental state of intention was isolated revealed a developmental shift in their concept of intention between 4 and 5 years of age. To examine whether there was a link between children's performance on intention tasks in infancy and the preschool years, we computed Pearson correlations between all of these dependent variables. We found a significant positive correlation between the percentage of time children imitated the intentional action first and their score in the HNP condition of the preschool task, $r=0.50$, $p<.01$. No other correlations reached statistical significance.

Our second question of interest was whether there was continuity between children's performance on the action imitation task at 14-18 months and their more general concept of the mind during preschool years, as measured by their performance on either the standard false-belief task or the Theory of Mind Scale. All of the children who participated in the present study completed the false belief task. Ten of the children passed this task and 21 of them failed. Point Biserial correlations were computed with the two dependent variables reflecting children's performance on the action imitation task in infancy. No statistically significant relationships were found. As outlined earlier, the children initially tested at 18 months (n=16) completed the Theory of Mind Scale. It was noted that their total scores on the Theory of Mind Scale ($M=2.88$, $SD=1.36$, range=0-5) were comparable to those obtained by children ranging from 50-53 months of age in another recent study ($M=2.9$, range=0-5) (Wellman & Liu, 2004). Because children's performance on the false-belief task was coded separately, the dependent variable used for the present study was children's score on the other 4 tasks comprising the Theory of Mind Scale ($M=2.56$, $SD=1.09$, range=0-4). Pearson correlations were computed between this score and the dependent variables characterizing the imitation task. No significant relationships were found.

Next, we examined whether children's performance across the three preschool tasks was related. First, Pearson correlations were computed between children's score on the PPVT ($M=100.03$, $SD=13.95$, range=56-129) and the two dependent variables reflecting their performance on the target-hitting game. No significant correlations were found. Second, we ran a Point Biserial correlation between children's performance on the false-belief task and their scores on the PPVT. Not surprisingly, we found that children with better general language skills were also more likely to pass the false-belief task ($r_{pbi}$=0.48, $p$<.05.). We also ran a Pearson correlation between children's PPVT and their score on the Theory of Mind Scale and found no significant relation. Furthermore, to examine the coherence between preschoolers' concept of intention and their knowledge of other mental states, we computed Point Biserial correlations between children's performance on the false-belief task and their scores on the two dependent variables reflecting their performance on the target-hitting game. No significant correlations were found. We also ran Pearson correlations between their scores on the Theory of Mind Scale (excluding the false-belief task) and their scores on the two dependent variables characterizing the target-hitting game (n=16). Again, no significant correlations were found. Finally, we ran a Point Biserial correlation between children's performance on the false-belief task and the other four tasks comprising the Theory of Mind Scale. As expected, we found that children who passed the false-belief task also performed better on the Theory of Mind Scale, ($r_{pbi}$=0.65, $p$<.05).

In the next series of analyses, we examined whether there was continuity between children's general language skills between 14 and 18 months and their performance on ToM tasks at 4 years of age. First, we ran Pearson correlations between children's total score on the MCDI at 14-18 months and the dependent variables characterizing their performance on the target-hitting game at 50 months. No statistically significant correlations emerged. Next, we computed a Point Biserial correlation between children's total scores on the MCDI at 14-18 months and their performance on the standard false-belief task at 50 months. Interestingly, we found that children who scored higher on the MCDI in infancy were also more likely to pass the false-belief task at 50 months ($r_{pbi}$ =.45, $p$<.05). We also correlated children's total scores on the MCDI at 14-18 months and their performance on the Theory of mind Scale, excluding the false-belief task. This relationship was not significant.

Our final question of interest was whether there is continuity between children's use of internal state terms at 32 months and their performance on ToM tasks at 50 months. As described earlier, parents of 26 of the children who participated in this follow-up investigation also provided data regarding their child's internal state language at 32 months of age. For this sub-set of children, there continued to be sufficient variability in their internal state language production ($M$=47.35, $SD$=18.34, range=10-72). We computed Pearson correlations between children's internal state language and their performance on the target-hitting game according to the two dependent variables outlined previously. No statistically significant correlations emerged. Next, we computed a Point Biserial correlation between their performance on the false-belief task and their previous internal state language production. The results indicated that children who passed the false-belief task at approximately 50 months also produced more internal state terms at 32 months of age ($r_{pbi}$ =.43, $p$<.05). Finally, we computed a Pearson correlation between children's score on the other four tasks comprising the Theory of Mind Scale, and their previous internal state language production. Once again, we found a predictive relationship ($r$ =.55, $p$<.05). In order to account for the effect of language, a partial correlation controlling for children's score on the PPVT, was computed. This correlation was marginally significant, indicating that children's use of internal state language at 32 months predicts their performance on the Theory of Mind Scale, even when general language abilities are accounted for ( $r$=.51, $p$=.07). All correlations computed between children's performance on the infant imitation task, internal state language, and preschool theory of mind tasks are represented in Table 2.

To summarize, the present study revealed a significant positive relationship between children's ability to differentiate between intentional and accidental actions in infancy and their later, more advanced, concept of intention in the preschool years. Specifically, we found that children who were more likely to reproduce the intentional action before the accidental action during the infant imitation task were also more likely to perform better on the target-hitting game. To our knowledge, this is the first study to provide preliminary evidence for a long-term association between children's implicit and explicit understanding of intention, from infancy to the preschool years. As expected, we also found a significant predictive relationship between infants' general vocabulary in the second year (i.e., MCDI scores) and their later performance on the false-belief task. Moreover, consistent with findings from other laboratories (e.g., Wellman et al., 2004), we found a significant link between children's scores on the PPVT and their performance on the false-belief task. An interesting finding from this research was that children's use of internal state language at 32 months predicted their performance on the false-belief task. Furthermore, children who produced more internal state terms at 32 months also scored higher on the other four tasks comprising the Theory of Mind Scale. Importantly, this predictive relationship was not uniquely language driven, as the correlation remained marginally significant when general language abilities were accounted for. These

Table 2

*Intercorrelations between children's performance on infant imitation task, internal state language, and their performance on preschool theory of mind tasks*

| | HNP | MP | FB | ToM Scale (n=16) |
|---|---|---|---|---|
| Infant task: Intentional action first | .50** | -.18 | .05 | -.02 |
| Infant task: Difference Score | .19 | -.01 | -.10 | -.07 |
| MCDI score (14-18 months) | .02 | -.16 | .45* | .42 |
| Internal state language at 32 months (n=26) | -.14 | .06 | .43* | .55* |
| Target-hitting game: HNP score (HNP) | | -.26 | -.16 | -.19 |
| Target-hitting game: MP score (MP) | | | -.04 | .00 |
| False-Belief Task (FB) | | | | .65* |

** $p<.01$, * $p<.05$

findings provide further evidence to suggest that there is a long-term association between children's early talk about the mind and their later ToM skills.

## Discussion

Despite the fact that there is much speculation about the foundations of ToM in infancy, there has been little empirical evidence to support the claims that early social-cognitive abilities are precursors to a ToM. Only a handful of studies have examined the developmental continuity in precursors of ToM concepts such as desire, intention, and attention. In a recent paper, Wellman et al. (2004) reported a correlation between 14-month-old infants' attention decrement in a task measuring goal-directed action and their later ToM skills. However, these findings might simply reflect a general developmental status effect similar to the well-known relationship between attention decrement and later IQ (McCall & Carriger, 1993). The present study is the first to show that there may be relationships between children's early forms of intention understanding in infancy, their use of internal state language, and their more advanced understanding of the concept of intention at preschool age.

More specifically, the results from the present experiment suggest that there is a link between children's ability to differentiate between intentional and accidental actions in infancy and their later, more advanced, concept of intention in the preschool years. In particular, we found that children who were more likely to reproduce the intentional action first during the imitation task also performed better on the preschool intention task. The other dependent variable reflecting infants' imitation of intentional actions did not correlate with preschool measures. This is likely due to the fact that this dependent measure had reduced variability. Interestingly, the outcome variable from the preschool intention task that yielded positive findings is the critical condition, that is, the one that requires understanding of intention as distinct from desire. The present study provides preliminary evidence to suggest that there is developmental continuity between children's understanding of intention-in-action in infancy and their later, more advanced, understanding of intention in the mind. The fact that a long-term longitudinal association was observed between tasks that measure the same construct (i.e., intention) is an important finding. This data is consistent with a theoretical account that emphasizes infants' early sensitivity to the intentional structure of people's actions as playing a key role in children's developing understanding of people as mentalists. This finding seems to contrast with one previous longitudinal study that reported no association between imitation skills at 20 months and a battery of theory of mind abilities at 44 months (Charman et al., 2000). However, rather than testing general imitation skills per se, the task that we administered at 14 and 18 months tapped into infants' ability to differentiate intentional from accidental actions, using a range of behavior cues such as gaze, gestures, and vocalizations. As such, the present imitation tasks probably required good joint attention skills, which are themselves predictive of concurrent imitation of intentional actions and later theory of mind (Camaioni, Perucchini, Bellagamba, & Colonnesi, 1994; Charman et al., 2000). Thus, infants' ability to monitor and imitate the goals or intentions underlying other people's actions might be one of the critical steps towards developing a full-fledged concept of intention. Unexpectedly, we did not find that children's performance on the imitation task in infancy was related to their later understanding of false-belief or other mental states (e.g., desire, knowledge, emotion). As such, future research is warranted to examine whether a battery of infancy tasks tapping into a wide range of mental states would predict performance on the Theory of Mind Scale at preschool age. To our knowledge, the present investigation included the largest sample of children ever tested in a longitudinal study examining ToM from infancy to the preschool years. Nevertheless, it is possible that more significant relationships between concepts in infancy and the preschool age may have been detected with a larger sample size. This limitation should also be addressed in future longitudinal investigations.

Another important finding of the present study is that internal state language is highly predictive of later ToM. Specifically, we found that there was a significant relationship between children's use of internal state terms at 32 months and their general concept of the mind at 50 months, as measured by the false-belief task. There was also a significant positive correlation between children's internal state term production at 32 months and their performance on the other four tasks comprising the Theory of Mind Scale, even when general language skills (i.e., PPVT) were partialled out. By demonstrating that children's internal state language is highly predictive of ToM skills approximately 2 years later, this study extends previous research that has shown a similar link during the preschool period (Brown et al., 1996; Ruffman et al., 2002). Moreover, the strong link that we observed between the number of internal terms produced by children at 32 months and their performance on ToM tasks at 4 ½ years supports the hypothesis that talking about mental states helps children learn about the mind (Hugues & Dunn, 1998; Ruffman et al., 2002). With respect to ToM and general language skills, the present study also went beyond previous research in uncovering a significant predictive link between general language and ToM over the largest developmental span ever studied, that is, between 14 and 54 months. We found a significant correlation between children's scores on the PPVT and their performance on the false-belief task, which replicates previous research (Astington & Baird, 2005). In contrast, we did not find that children's scores on the PPVT were significantly related to their performance on the other four tasks that comprise the Theory of Mind Scale. These results replicate the findings reported by Wellman et al. (Wellman et al., 2004), who also demonstrated that the Theory of Mind Scale is a less language-laden measure of ToM.

In conclusion, results from the present study are consistent with the hypothesis that there is continuity in social cognition between infancy and early childhood. This longitudinal study cannot answer questions about the mechanism by which precursors, such as the ones we have uncovered, affect later abilities. However, our demonstration of developmental continuities in the realm of social cognition provides critical information with regards to the controversy about the nature of early social-cognitive abilities (see Perner & Ruffman, 2005 for a lean interpretation of nonverbal tasks of mindreading skills). We believe that the results of the present investigation provide preliminary evidence to support the hypothesis that imitation of intentional actions and internal state language production tap into infants' early concept of the mind. Regardless of whether these precursors reflect infants' ability to acquire sophisticated behavioral rules or an implicit ToM, the present findings indicate that these abilities are somehow related to the acquisition of a full-fledged ToM.

# Chapter 4: Conclusion

*Summary of findings*

The purpose of the present dissertation was to investigate infants' understanding of intentional action. Two longitudinal studies were conducted in order to address two critical issues. First, are the experimental tasks that are currently being used to tap infants' understanding of intentional actions actually measuring the same underlying skills? Second, is there developmental continuity between children's early understanding of intentional action and their later, more advanced, theory of mind skills?

The first paper (Olineck & Poulin-Dubois, submitted) examined whether infants' performances on different tasks commonly assumed to measure intention/goal understanding are related, as implied in the extant literature. Participants completed two visual attention tasks (i.e., the goal detection task and the action parsing task) at 10 months and then returned to the laboratory to complete two imitation tasks (i.e., the selective action imitation task and the behavioral re-enactment task) when they were approximately 14 months of age. Interestingly, an association was observed between infants' decrement of attention scores on the two visual attention tasks administered at 10 months. Unexpectedly, infants performances on the two imitation tasks administered at 14 months were unrelated. An important finding of this study was that infants' looking behavior during the goal detection and action parsing tasks predicted their performance on only one of the imitation tasks administered approximately four months later. Specifically, infants' decrement of attention scores on the goal detection and action parsing tasks were correlated with their ability to infer the intended goal underlying a failed attempt at 14 months. Surprisingly, infants' performances on the two visual attention tasks were not linked to their performance on the selective action imitation task. Given the lack of correlations between infants' performances on the selective action imitation task and the other three measures, the results of this study suggest that this imitation task may be tapping into different social cognitive abilities. Nevertheless, the findings provide preliminary evidence to suggest that the goal detection, action parsing, and behavioral re-enactment tasks are measuring related underlying skills.

The second paper (Olineck & Poulin-Dubois, 2007) addressed whether there are developmental continuities between children's understanding of intentional action in infancy and their ToM skills during the preschool period. The relationships between children's early talk about the mind (i.e., internal state language) and later ToM abilities were also studied. Between the ages of 14 and 18 months, infants were administered a selective action imitation task. At 32 months, parents completed a questionnaire regarding their child's use of internal state terms. Finally, at approximately 50 months of age, children completed an intention task, a battery of ToM tasks, and a vocabulary measure. Interestingly, results indicated that children's early ability to differentiate intentional and accidental actions was correlated with their ability to distinguish intention from desires in the preschool period. However, children's performance on the selective action imitation task in infancy was not associated with their performance on more general measures of ToM later on. Another key finding in this paper was that children's talk about mental states (i.e., internal state vocabulary) predicted their performance on ToM tasks in the preschool period, even when receptive language skills were accounted for. Taken together, these results add to the body of evidence that supports the developmental continuity hypothesis and suggest that children's understanding of intentional action and use of internal state language may be important precursors to later ToM.

Overall, the findings from the two papers presented in this dissertation shed light on the development of children' understanding of intentional actions in two ways. First, by including a variety of experimental tasks designed to measure intention understanding, this series of papers provide empirical evidence to suggest that some of these tasks are indeed measuring related underlying skills. Surprisingly, results indicate that the selective action imitation task may be tapping into different social cognitive abilities. Second, by testing the same children from infancy to early childhood, results from this dissertation add to the body of evidence that suggests that there is developmental continuity in children's understanding of intention from infancy through the preschool years. Moreover, results indicate that children's early talk about the mind is highly predictive of later ToM abilities. Together, these studies also highlight the value of using longitudinal and within subjects designs to investigate precursors to theory of mind in infancy.

*Contributions to the literature*

Over the past two decades, cognitive developmental scientists have made exciting progress with respect to investigating the extent to which infants explain and predict human actions in terms of psychological states (Meltzoff, Gopnik, & Repacholi, 1999; Poulin-Dubois, 1999; Woodward, 2005). Infants seem to possess some rudimentary understanding of intentional action early on. As such, it has been proposed that understanding people as intentional agents may represent children's first step towards developing a full-fledged ToM (e.g., Tomasello, Kruger, & Ratner, 1993). Theoretically, it seems plausible that infants may possess an implicit understanding of intentions that becomes more and more explicit as they age (Colonnesi et al., in press). However, until recently, there was little empirical evidence to substantiate this claim. Moreover, the studies that have investigated early precursors to ToM have been the subject of much debate. The crux of this debate centers on issues of interpretation. Preschoolers are required to explicitly demonstrate their mental state attributions by answering verbal questions about other's thoughts, feelings, and behaviors during experimental tasks (e.g., Wellman & Liu, 2004). Moreover, the false belief task has undergone thorough replication and is now sanctified as the litmus test for ToM. In contrast, infancy researchers (and primatologists) have had to devise innovative methods for testing preverbal children's understanding of people as intentional agents. The results gleaned from these tasks are inherently more ambiguous; therefore, there is significantly more room for interpretation. The current debate regarding 15-month-olds' ability to attribute false beliefs is an excellent illustration of the extent to which data interpretations may differ among researchers in the field (i.e., Onishi & Baillargeon, 2005 versus ; Perner & Ruffman, 2005).

As mentioned earlier, some researchers argue that infants' behavior during this type of task demonstrates their mentalistic understanding. Others argue that this interpretation is too "rich" and that infants' ability to predict how a person will act could be based simply on learned rules about behavior (Perner & Ruffman, 2005). Part of this contentious debate between "lean" versus "rich" interpreters in the field stems from the fact that these nonverbal infancy tasks have yet to be empirically validated. Construct validity refers to whether an empirical task taps the unobservable construct (i.e., concept of goal/intention) that it claims to measure. In order to achieve construct validity, researchers must do the following: (1) generate a comprehensive definition of the construct, (2) translate this construct into specific experimental operations, and (3) obtain data to show that results from the measure being evaluated are positively correlated with other variables that are known to be related to the construct or that are theoretically linked (Christensen, 1997; Cook & Campbell, 1979). To date, infancy researchers seem to have a preliminary working definition of the concept of goals and/or intention. However, they have not yet provided sufficient evidence to suggest that an adequate translation of the conceptual variable (i.e., concept of intention) has been attained.

One way for cognitive developmental scientists to establish the validity of a particular intention task is to determine the degree to which that operationalization relates to other intention tasks that are administered at the same time (Christensen, 1997). The first paper represents an important contribution to the field because it is the first study in the field of cognitive development to systematically investigate children's concurrent performance on different tasks designed to measure goal/intention understanding in infancy. The findings from this study suggest that goal detection, action parsing, and behavioral re-enactment tasks may be tapping into similar underlying skills. Interestingly, these three tasks tapping infants' understanding of intentional actions also all involve some sort of action violation. Surprisingly, results from this paper indicated that infants' looking behaviors during the two visual attention tasks were not associated with their performance on the selective action imitation task. Moreover, infants' concurrent performances on the behavioral re-enactment task and the selective action imitation task were unrelated. Some researchers have argued that infants' reproduction of failed attempts may be due to emulation learning, rather than an ability to infer underlying intentions (Huang, Heyes, & Charman, 2002, 2006). In contrast, the selective action imitation task, which requires infants to distinguish intentional from accidental actions, may require a deeper understanding of intentionality. Interestingly, both the behavioral re-enactment and selective action imitation tasks have been found to predict preschoolers' concept of intention (Colonnesi et al., in press; Olineck & Poulin-Dubois, 2007). Further replications are needed to determine the extent to which infants' performances on these tasks are related to their performance on other concurrent measures of intention understanding. Future studies should also address whether children's performance on the behavioral re-enactment task is linked with later use of internal state language, as has been shown for the selective imitation task (Olineck & Poulin-Dubois, 2005).

Importantly, infants' performances on the two visual attention tasks measuring goal-detection and action parsing abilities were found to be related. More specifically, infants' attention to the events used for both tasks was positively correlated. It is possible that infants' attention scores during these tasks were coordinated simply because infants' processing speed is a stable trait, regardless of the nature of the stimuli (social or physical). However, it is also possible that infants who were more sensitive to the structure of intentional action were also more sensitive to the goals underlying human behavior, and were thus able to process this information at a faster rate. This significant correlation was impressive, given that infants were presented with live events during one task and video-clips during the other. Unfortunately, without the inclusion of a control task, it is not possible to rule out the possibility that the correlations found between infants' decrement of attention scores on the two visual attention tasks were not due to other determinants of task performance (i.e., general intelligence, executive functioning skills, or information processing speed) in this study. However, it is our belief that the correlations found between infants' performances on these visual attention tasks provide preliminary evidence to suggest that these tasks are both measuring some understanding of intentional action. The fact that infants' decrement of attention scores on these tasks also predicted their subsequent performance on the behavioral re-enactment task also speaks to the validity of these measures. The present dissertation offers preliminary evidence to suggest that some of the tasks currently being used to measure intentional action understanding are indeed measuring related abilities. However, the results also raise important questions regarding the abilities that are being measured by the selective action imitation task. If, as the extant literature seems to assume, these tasks are all measuring some form of intention understanding, infants' performances should be linked. The present dissertation indicates that this is true for some tasks, but that this assumption should continue to be empirically tested with the inclusion of appropriate nonsocial control tasks.

Another way to test the validity of the tasks being used to measure infants' understanding of intentional action is to conduct longitudinal research. If infant tasks are tapping into some form of intention understanding, then there should be long term associations between children's behavior on these infancy measures and their behavior during preschool tasks that assess ToM skills. To date, only a handful of such longitudinal research studies have been conducted. The majority of these investigations have documented social cognitive continuity for measures of attention during infant habituation tasks (e.g., Aschersleben et al., in press; Wellman et al., 2008; Wellman et al., 2004). A strength of the current dissertation is that other measures (i.e., imitation) were also used to capture infants' intention understanding. Results indicated that there is developmental continuity in children's understanding of intentional action from infancy to the preschool period. The short- and long-term associations that were found between tasks designed to measure the same construct (i.e., intention) in different age groups (i.e., infancy and preschool period) also speak to the validity of the visual attention and imitation tasks used in infancy. Interestingly, infants' performance on the selective action imitation task was linked with their performance on a preschool intention task but not with their performances on tasks measuring more general ToM skills (i.e., ToM Scale, False-belief task). In contrast, previous research using infant habituation tasks have found long-term associations between infants' understanding of intentional action and preschoolers general ToM abilities (e.g., Aschersleben et al., in press; Wellman et al. 2004; Wellman et al., 2008). Once again, this finding suggests that the selective action imitation task may be tapping into different social cognitive abilities. However, it is our belief that these skills are still related to the acquisition of theory of mind, as infants' performance on this task has been found to be linked with their use of internal state language and their performance on a verbal intention task later on (Olineck & Poulin-Dubois, 2005, 2007).

Another significant contribution of the current dissertation is the finding that young children's internal state language was highly predictive of later ToM. Recall that we found that 32-month-olds' use of internal state terms predicted their performance on the false-belief task and other ToM tasks at 50 months, even when general language abilities were accounted for (Olineck & Poulin-Dubois, 2007) . As mentioned previously, Olineck and Poulin-Dubois (2005) found that infants' performance on the selective action imitation task also predicted their use of internal mental state terms later on. Because infants' performances on the selective imitation task correlated with internal language, as one would predict based on theory, these results provide further evidence to support the validity of this measure of intention. Furthermore, the results described in Olineck and Poulin-Dubois (2005, 2007) add to the body of evidence that suggests that talking about mental states helps children learn about the mind (Hugues & Dunn, 1998; Ruffman et al., 2002).

Taken together, results from the current dissertation offer important information and identify exciting new research questions for cognitive developmental scientists. Given the concurrent links that were found across infants' performances on different experimental tasks, results from the present series of studies provide preliminary evidence to support the validity of the nonverbal methods currently being used to measure precursors to theory of mind in infancy. Our demonstrations of developmental continuities in the realm of social cognition further support the validity of the nonverbal tasks used to measure intention understanding in infancy. In addition, the associations that were found between children's performance on intentional action understanding tasks in infancy and preschool theory of mind tasks provide preliminary evidence to support the developmental continuity hypothesis.

The findings reported in the present dissertation are also relevant to existing theories regarding ToM development in childhood. Current theories on ToM stem from nativist or constructivist traditions. Nativist theories emphasize a child's innate understanding of the mind and the role of maturation (Meltzoff, 1999). For example, Leslie, Freidman, and German (2004) have proposed that concepts of the mind are introduced into the child's cognitive system by an innate "theory of mind mechanism," a part of the core architecture of the brain that is specialized for learning about mental states. According to Leslie and his colleagues, children's acquire "mind reading" abilities because of the activation of a specialized neurocognitive mechanism. In contrast, constructivists propose that children develop their understanding of the mind by experimenting in the world around them (Meltzoff, 1999). Like scientists, children observe the behavior of other people, generate hypotheses about how mental states influence behavior, and revise their understanding based on the information or feedback they receive (Meltzoff, 1999). For example, Moore (2007) has suggested that children learn about the world by adopting other people's intentional relations to object and events during social interactions. According to Tomasello and his colleagues (Tomasello et al., 2005), human beings are particularly skilled "mind readers" because of a strong desire to share emotions, experiences, and activities with other people. Moreover, these researchers suggest that understanding intentions is a foundational skill in ToM development because it provides a framework within which to interpret human behavior. Tomasello et al. (2005) proposed that infants progress through three levels of intention understanding. First, they are capable of detecting biological motion and are sensitive to self-propulsion. In the second phase, infants understand that people have goals and behave accordingly. Finally, infants come to understand that, in pursuing a goal, people generate specific plans of action and then choose which plan to enact based on their intentions and goals. Like traditional Piagetian theories of development, Tomasello and his colleagues (2005) posit that children's experiences foster their progress through these phases. Based on the constructivist theoretical account, one would expect to observe a developmental progression in children's concept of intention from infancy through early childhood. The fact that children's early understanding of intentional action was found to be related to their use of internal state language and their more sophisticated concept of the mind in preschool lends support to the notion that children's experiences play a role in their development of theory of mind.

*Future Directions*

One limitation of the current dissertation is that the final samples in both studies are small. It is likely that more significant relationships between tasks and age groups would have been detected with larger sample sizes. Moreover, with a larger sample sizes, data could have been analyzed using regression analyses to determine causal links. Unfortunately, small sample size is a common drawback with longitudinal designs. Indeed, most of the longitudinal studies published on ToM have reported results from relatively small samples. For example, longitudinal associations have been uncovered in studies involving 13 children (Charman et al., 2000), 18 children (Wellman et al., 2004), and 20 children (Aschersleben et al., in press). Future research should aim to test larger numbers of children in infancy so that, even with attrition, investigators have enough statistical power to uncover potential links. However, it is important to highlight that, despite small sample sizes, the current dissertation uncovered important and meaningful links between infants' performance on various intention tasks. For instance, strong predictive relationships were observed between infants' abilities to detect an incomplete intentional action and parse actions along intentional boundaries at 10 months and their ability to infer the intended goal of a failed attempt at 14 months. In the second paper, robust long-term associations were found between 14- to 18-month-old infants' ability to differentiate intentional and accidental actions and their ability to distinguish intention from desires at approximately 50 months of age.

One might argue that the developmental continuity observed between infants' and preschoolers' concept of intention merely confirms that children who are cognitively advanced in infancy also tend to perform better on most cognitive tasks in preschool. Although we included a measure of language skills (i.e., PPVT) in the second paper, it would be beneficial for future research to include control tasks measuring general intelligence, executive functioning, and verbal competence. Interestingly, researchers have recently completed studies with these control measures and still found specific long-term associations between infant social attention and preschool theory of mind (e.g., Wellman et al., 2008). It would also be interesting to explore whether training programs designed to foster ToM skills in infancy would have an impact on children's later ToM skills.

Another important area for future research is to study whether similar developmental continuities emerge when other infant measures are used. For example, in the current dissertation, infants' performance on action parsing tasks predicted their ability to detect intentions underlying false attempts four months later. It would be interesting to determine whether children's sensitivity to the inherent structure of intentional action at 10 months would also be linked to their general theory of mind abilities (i.e., performance on the Theory of Mind Scale) later on. Ultimately, once a number of longitudinal studies have been conducted on the various infant measures, it will be very useful for the field to conduct a meta- analysis of these results. By combining the results of several studies, a meta-analysis would help address the issue of limited statistical power (i.e., due to small sample sizes) and allow for more accurate data analyses.

The results from the present dissertation also have important implications for researchers and practitioners in other fields such as clinical psychology (Flavell, 2004). It has been well-documented that children diagnosed with Autism Spectrum Disorders have difficulty understanding other people's knowledge and beliefs (Baron-Cohen, 2000). Moreover, theory of mind deficits have been used to explain autistic children's atypical social behavior (e.g., lack of social awareness, one-sidedness in interactions; (Happe, 1994), communication development (e.g., delay or lack of speech development, stereotyped and repetitive use of language, abnormalities of prosody, repetitive use of language; (Tager-Flusberg, 1993), and absence of pretend play (Happe, 1994) . Once researchers have identified precursors of theory of mind in infancy, as well as empirically validated methods of measuring these abilities, they can collaborate with clinicians to design and test early screening tools for children at risk of developing autism spectrum disorders. The results of the present dissertation suggest that further research is needed to explore whether some of these intention tasks could eventually be used as early screening tools for autism. Future research should explore this possibility in more depth.

In summary, longitudinal investigations represent an important new approach to studying theory of mind. It is logical to assume that children gradually converge on an adult-like theory of mind, with precursors to ToM in infancy (Flavell, 1999). However, more empirical evidence, derived from longitudinal studies, is necessary to verify this theoretical account. The findings from the present dissertation offer exciting new insights to the field of cognitive development. These papers provide preliminary empirical evidence to suggest that visual attention and imitation tasks tap infants' early understanding of intentional actions. As such, these findings provide preliminary evidence to support the validity of these experimental measures. Furthermore, results from this dissertation are consistent with the hypothesis that there is continuity in social cognition between infancy and early childhood. Specifically, infants' ability to differentiate intentional from accidental actions is related to their ability to distinguish intention from desires in the preschool period. Furthermore, children's early use of internal state language is predictive of their ToM abilities later on. Overall, these findings provide valuable insight into the developmental progression of intention understanding from infancy to preschool and suggest that knowledge of intentional action represents an important step towards developing a theory of mind.

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Appendix A

Sample Recruitment Letter

(Chapter 2)

November 2005

Dear Parents,

The Child Development Laboratory at Concordia University is involved in a series of studies looking at how infants understand human actions and mental states. 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 birth list of January 2005 which indicates that you have a child of an age appropriate for our study.

The present study involves two tasks. In the first task, we are investigating infants understanding of purposeful actions. Specifically, we are interested in knowing if infants will notice when an agent's action is interrupted before having completed an obvious goal (e.g., a pause just before a hand takes away a toy). Infants will be shown movies depicting a person completing simple actions. Your child will be presented the films on a computer screen and the amount of time he or she looks at each film will be recorded. In the second task, we are studying whether infants understand the relation between a person and the object of her gaze. First, infants will be shown an actor turn and look repeatedly at one of two toys. Then, a curtain will be drawn and the location of the toys will be switched. Finally, infants will see two types of events: (1) the actor will turn to the same side but look at a new toy; (2) the actor will turn to the opposite side but look at the same toy. The amount of time that your child looks at each demonstration will be recorded. During these tasks, your child will be sitting in a child seat and you will be seated directly behind. The videotapes and all the data obtained from your child will be kept confidential.

Participation involves one visit of approximately 45 minutes to our research centre on the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West. Appointments can be scheduled at a time convenient to you, including weekends. Free parking is available on the campus for our participants, and we will gladly reimburse any transportation expenses at the time of your appointment. Upon completion of the study, a Certificate of Merit will be given to your child, and a report of the results of the study will be mailed to you as soon as it is completed.

For the purposes of this study, we are looking for infants who are 10 months of age, whose parents speak either English or French at 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 Aguy Moryoussef or Kara Olineck 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.

Thank you for your interest and collaboration.

| | | |
|---|---|---|
| Diane Poulin-Dubois, Ph.D. | Kara Olineck, M.A. | Aguy Moryoussef, B.A. |
| Professor | Ph.D. Candidate | Research Assistant |
| Department of Psychology | Department of Psychology | Department of Psychology |

(Français au verso)

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 and Kara Olineck of Concordia University.

**A. PURPOSE**
I have been informed that the purpose of the research is to examine how infants understand human actions and mental states.

**B. PROCEDURES**
In this study, your child will complete two tasks. In the first task, we are investigating infants' understanding of purposeful actions. Specifically, we are interested in knowing if infants will notice when a person's action is interrupted before having completed an obvious goal (e.g., a pause just before a hand takes away a toy). Infants will be shown movies depicting a person completing simple actions. Your child will be presented the films on a computer screen and the amount of time he or she looks at each film will be recorded. In the second task, we are studying whether infants understand the relation between a person and the object of her gaze. First, infants will be shown an actor turn and look repeatedly at one of two toys. Then, a curtain will be drawn and the location of the toys will be switched. Finally, infants will see two types of events: (1) the actor will turn to the same side but look at a new toy; (2) the actor will turn to the opposite side but look at the same toy. The amount of time that your child looks at each demonstration will be recorded. During these 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. 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 data collected in this study. 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 the follow up study with my child at 14 months?**
**(yes/ no): ________**

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.
Professor
Department of Psychology
848-2424 ext.2219
diane.poulindubois@concordia.ca

______________________
Kara Olineck, M.A.
Ph.D. Candidate
Department of Psychology
848-2424 ext.2279
olineck@alcor.concordia.ca


Participant # ____________

Appendix C

Participant Information Form

*Participant Information Form*

**Please answer the following general information questions about your child. All your responses will be kept confidential.**

Child's Name: ______________________________________________
(first and last name)

Date of Birth: ______________________________________________
(month/day/year)

Gender: _________ Language(s) spoken at home: ______________________________

Address: ______________________________________________

______________________________________________

Postal Code: ______________________________________________

Telephone: ______________________ (home) ________________________ (work)

________________________ (work)

Mother's Name: ____________________ Father's Name: ______________________

Occupation: ______________________ Occupation: ________________________

Education: ______________________ Education: ________________________
(highest level attained) (highest level attained)

Birth weight: ____________________

Circle one: First Born, Second Born, Third Born, Other (please specify) _____

Length of pregnancy: ____________________ weeks

Was your child born on time? Y/N If not, how early or late? ______________

Were there any complications during the pregnancy? ____________________________

______________________________________________

Has your child had any major medical problems? ______________________________

______________________________________________

Does your child have any hearing or vision problems? ___________________________

______________________________________________

Does your child have any siblings? Yes / No

If yes, how many? ________________________

Appendix D

Instructions Given to Parents

**Instructions for Parents**

1. When we enter the room where will be doing the study, please seat your child in the infant seat and sit behind your child in the chair provided.

2. Before we begin the task, please ensure that your infant has no toys or food, as these items may be distracting.

3. If possible, do not say anything and do not touch your child during the length of the experiment (about 20 minutes). Please do not point or call attention to any of the toys during the study.

4. During the experiment, your child will probably turn around and look at you a few times. If this occurs, you may respond by smiling, but please try not to say anything.

5. If your child becomes very fussy or starts to cry, we will pause the experiment to give you a chance to comfort him/her.

Appendix E

Sample Coding Form for Selective Action Imitation Task

(Chapter 2 and Chapter 3)

**Coding for Selective Action Imitation Task**
**(Based on Carpenter et al., 1998; Olineck & Poulin-Dubois, 2005)**

Subject number: ___________Coded by: ___________Date coded: ___________

Comments:_______________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

## Order 1

**Warm-Up:**

| Box | Did they imitate the action? Comments? |
|---|---|
| Box 1<br>(one device) | |
| Box 2<br>(two devices) | |

**Test Phase:**

| Trials | Box | Objects | | 1st Action | | 2nd Action | | Both Actions (same time) | Neither Action |
|---|---|---|---|---|---|---|---|---|---|
| | | Intentional | Accidental | | I or A? | | I or A? | | |
| Trial 1 | Box3 | Fish pull | Turn | | | | | | |
| Trial 2 | Box4 | Orange push | Beads | | | | | | |
| Trial 3 | Box5 | Yellow Slide | Turn Discs | | | | | | |
| Trial 4 | Box6 | Phone Dial | Sun Spin | | | | | | |

Appendix F

Coding Form for Behavioral Re-enactment Task

(Chapter 2)

**Coding Form for Behavioral Re-enactment Task**
**(Based on Meltzoff, 1995; Bellagamba et al, 2006)**

Subject number: ____________ Order: ____________ Coded by: ____________
Date coded: ____________
Comments:____________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

**Test Phase: "Demonstration of Intention" Condition**

| Trial | Object | Did the infant produce the end result? Circle | | Target Score | Comments |
|---|---|---|---|---|---|
| 1 | | Yes | No | | |
| 2 | | Yes | No | | |
| 3 | | Yes | No | | |
| 4 | | Yes | No | | |
| 5 | | Yes | No | | |

**TOTAL TARGET SCORE: ______ (/5)**

**Coding Form for Behavioral Re-enactment Task (cont.)**
**(Based on Meltzoff, 1995; Bellagamba et al, 2006)**

**<u>Post-Test Coding (i.e., experimenter demonstrated target action and child was given the opportunity to imitate)</u>**

| Trial | Object | Did the infant imitate the target action? Circle | | If not, what did they do with the object? | Comments |
|---|---|---|---|---|---|
| 1 | | Yes | No | | |
| 2 | | Yes | No | | |
| 3 | | Yes | No | | |
| 4 | | Yes | No | | |
| 5 | | Yes | No | | |

Appendix G

Sample Recruitment Letter

(Chapter 3)

May 2005

Dear Parents,

We would like to thank you for your past interest and participation in our research program and invite you to return to our laboratory for another study on cognitive development. As you may recall, your child participated in one of our research projects when they were approximately 18 months old. In this study, we were interested in examining when young children are able to differentiate between intentional and accidental actions. We found that 14-month-olds have some understanding of other people's intentions; however, this understanding is less advanced than that of 18-month-olds. In addition, you may recall providing us with information regarding the types of words your child was able to produce when he or she was approximately 30 months of age. In this study, our aim was to determine whether there is a link between infants' understanding of people's mental states and the types of words they are able to produce later on. Interestingly, we found a significant relationship between infants' use of mental terms (e.g., want, hope) and their prior understanding of intention. These findings are very exciting, and have recently been accepted for publication in a scientific journal called *Infancy*.

We are now eager to learn whether there is also a link between children's understanding of mental states in infancy and preschool. As such, we invite you to return to our laboratory with your child. Preschoolers will be asked to complete a number of fun interactive tasks, and will receive several toy prizes during the session. First, they will be given an opportunity to play a game in which they are required to make plastic cans fall in order to win prizes. Then, children will be presented with a series of stories and asked to guess what a puppet knows or prefers on the basis of these stories. We will also be investigating whether preschooler's vocabulary is related to their behavior during these tasks. To measure vocabulary, children will be asked to point to pictures that correspond to different words. Preschoolers' behavior during these tasks will be compared with the behaviors they exhibited during their first visit to our laboratory.

Participation would involve one visit of approximately one hour to our research centre on the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West. Appointments can be scheduled at a time convenient to you, including weekends. Free parking is available on the campus for our participants, and we will gladly reimburse any transportation expenses at the time of your appointment. In addition, a report of these results will be mailed to you as soon as the study is completed.

We would greatly appreciate your continued cooperation and interest in our research project. Research on children's early cognitive development is only possible thanks to the contribution of time and effort by families like you! If you would like further information about this study, have any questions about issues concerning cognitive development, or are willing to participate, please do not hesitate to contact Kara Olineck at 848-2424, ext. 2279 or Dr. Diane Poulin-Dubois at 848-2424, ext. 2219.

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

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

Kara Olineck, M.A.
Ph.D. Candidate
Department of Psychology

Appendix H

Sample Consent Form

(Chapter 3)

**Parental Consent Form**

The present investigation involves examining preschoolers' understanding of other people's mental states. Children will be asked to complete a number of fun interactive tasks, and will receive several toy prizes during the session. First, your child will participate in a game in which they will be required to hit a plastic can, with a remote control unit, in an attempt to win a prize. An experimenter hidden under a table will control which can will fall. Each child will participate in a total of 18 trials. Understanding of intention will be assessed by asking if they intended to hit the can that fell. Children will be allowed to keep all prizes that they win during the game. Then, your child will be presented with a series of stories, and asked to tell what a puppet knows or prefers on the basis of these stories. Your child will also be administered a standard vocabulary test, which involves pointing to pictures corresponding to different words. You will be able to watch your child from another room throughout the experimental session. Your child's responses will be written down and will be treated in the strictest of confidentiality. Because we are only interested in comparing childrens' understanding as a function of age, no individual scores will be provided following participation. The entire session is expected to last approximately 45 minutes.

______________________

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

______________________

Kara Olineck, M.A.
Ph.D. Candidate
Department of Psychology

The nature and purpose of this study have been satisfactorily explained to me and I agree to allow my child to participate. I understand that we are free to discontinue 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.

______________________

Parent's signature

______________________

Date

Participant # ________________

Appendix I

Mental Lexicon Questionnaire

(Chapter 3)

Name of child ______________________________

Date of birth ____________________ Date ____________

# *Mental Lexicon Questionnaire*

Cognitive Development Laboratory
Centre for Research in Human Development
Concordia University

## A. VOCABULARY CHECKLIST

Children understand many more words than they say. We are particularly interested in the words your child SAYS. Please go through the list and mark the words you have heard your child use. If your child uses a different pronunciation of a word, (for example, "raffe" instead of "giraffe" or "sketti" for "spaghetti"), mark the word anyway. Remember that this is a "catalogue" of all the words that are used by many different children. Don't worry if your child knows only a few of these right now.

Please darken the O for each word your child uses.

### 1. PERCEPTUAL

| | | | | | |
|---|---|---|---|---|---|
| See | O | Listen | O | Cold (feeling cold) | O |
| Look | O | Taste | O | Freezing | O |
| Watch | O | Smell | O | Hot(same as for cold) | O |
| Hear | O | Feel (soft, warm) | O | Warm (same as for cold) | O |
| Hurt | O | | | | |

### 2. PHYSIOLOGICAL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Hungry | O | Have fun | O | Have a good time | O | Hug | O |
| Starving | O | Funny | O | Surprised | O | Kiss | O |
| Thirsty | O | Proud | O | Sad | O | Laugh | O |
| Sleepy (I am sleepy) | O | Feel (good, bad) | O | Angry | O | Smile | O |
| Sleepy (I don't want to sleep) | O | To be all right | O | Mad | O | Cry | O |
| Asleep | O | Better | O | Scared | O | Want | O |
| Tired | O | Good(feel good) | O | Scary | O | Need | O |
| Awake | O | O.K. | O | Dirty | O | Have to | O |
| Wake up | O | Nice | O | Messy | O | Can | O |
| Sick | O | Like | O | Yucky | O | Hard | O |
| Happy | O | Love | O | Bad (feeling) | O | | |

| 3. COGNITION | | | | | |
|---|---|---|---|---|---|
| Know | O | May | O | Guess | O |
| Think | O | Understand | O | Mean (i.e. I mean) | O |
| Remember | O | Pretend | O | | |
| Forget | O | Dream | O | | |
| Maybe | O | Real | O | | |

| 4. MORAL JUDGEMENT AND OBLIGATION | | | |
|---|---|---|---|
| Good | O | Supposed to | O |
| Bad | O | Must | O |
| Naughty | O | Have to | O |
| May | O | Should | O |
| Let | O | Can (for permission) | O |

Appendix J

Coding Form for the Target-hitting Game

(Chapter 3)

*Coding Form for Target-hitting Game (i.e., Preschool Intention Task)*

| **Participant #** | |
|---|---|
| **Order #** | |

| **Date Coded** | |
|---|---|
| **Coded by** | |

**Warm-up:**

**I) Naming Colors**
(Check if child named color correctly):

yellow ______ green _____
red ______ purple _____
blue ______ orange _____

**II) Practice Shooting:**

Trial Comments
I ____________________________
II ____________________________

**Experimental Trials:**

| Trial | Condition | Child's Response (circle) | | Child's Score | Comments |
|---|---|---|---|---|---|
| 1 | HP | yellow* | Red | | |
| 2 | HN | red* | Green | | |
| 3 | MP | red | green* | | |
| 4 | HN | yellow* | Red | | |
| 5 | MP | orange | purple* | | |
| 6 | HN | blue* | Green | | |
| 7 | MN | purple | orange* | | |
| 8 | HP | blue* | Green | | |
| 9 | MN | green | red* | | |
| 10 | HP | orange* | Purple | | |
| 11 | MN | red | yellow* | | |
| 12 | MP | blue | green* | | |
| 13 | HN | green* | Red | | |
| 14 | MN | purple | blue* | | |
| 15 | HP | purple* | Blue | | |
| 16 | MP | orange | purple* | | |

*Note: Correct response is indicated by asterisk*

| HP Score | HN Score | MP Score | MN Score |
|---|---|---|---|
| 4 | 4 | 4 | 4 |

| Total Score |
|---|
| 16 |

Appendix K

Protocol for Theory of Mind Scale

(Chapter 3)

**Protocol for Theory of Mind Scale**
**Adapted Directly from Wellman & Liu, 2004**

**1) Diverse Desires Task:**

**Experimenter:** "I have something to show you".

The child is shown a toy figure of an adult and a sheet of paper with pictures of a carrot and a cookie on it.

**Experimenter:** "Here's Mr. Jones. It's snack time so Mr. Jones wants a snack to eat. Here are two different snacks: a carrot and a cookie. Which snack would you like best? Would you like a carrot or a cookie best?" *(Own desire question)*

**If the child chooses the carrot...**

> **Experimenter**: "Well, that's a good choice, but Mr. Jones really likes cookies. He doesn't like carrots. What he likes best are cookies".

**If the child chooses the cookie...**

> **Experimenter**: "Well, that's a good choice, but Mr. Jones really likes carrots. He doesn't like cookies. What he likes best are carrots".

**Experimenter:** "So, now it's time to eat. Mr. Jones can only choose one snack, just one. Which snack will Mr. Jones choose? A carrot or a cookie?" *(Target question)*

Note: To be correct, or to pass this task, the child must answer the target question correctly (opposite from his or her answer to the own desire question)

**2) Diverse Beliefs Task:**

**Experimenter:** "I have something to show you".

The child is shown a toy figure of a girl and a sheet of paper with pictures of bushes and a garage on it.

**Experimenter:** "Here's Linda. Linda wants to find her cat. Her cat might be hiding in the bushes or it might be hiding in the garage. Where do you think the cat is? In the bushes or in the garage?" *(Own belief question)*

**If the child chooses the bushes...**

> **Experimenter**: "Well, that's a good idea, but Linda thinks her cat is in the garage. She thinks her cat is in the garage".

**If the child chooses the garage...**

> **Experimenter**: "Well, that's a good idea, but Linda thinks her cat is in the bushes. She thinks her cat is in the bushes".

**Experimenter:** "So, where will Linda look for her cat? In the bushes or in the garage?" *(Target question)*

Note: To be correct, or to pass this task, the child must answer the target question correctly (opposite from his or her answer to the own belief question)

**3) Knowledge Access Task:**

**Experimenter:** "I have something to show you".

The child is shown a plastic table with a drawer containing a small plastic toy cat inside the closed drawer.

**Experimenter:** "Here's a drawer. What do you think is inside the drawer?" *(Own belief question)*

The child can give any answer he/she likes or indicate that he/she does not know.

Experimenter opens the drawer and the child is shown the contents of the drawer.

**Experimenter:** "Let's see…it's really a cat inside!"

Experimenter closes drawer.

**Experimenter:** "Okay, what is in the drawer?"

The child is shown a toy figure of a girl.

**Experimenter:** "Polly has never ever seen inside this drawer. Now here comes Polly. So, does Polly know what is in the drawer?" *(Target question)*

**Experimenter:** "Did Polly see inside this drawer?" *(Memory question)*

Note: To be correct, or to pass this task, the child must answer "no" to the target question and "no to the memory control question.

**4) Contents False Belief Task:**

**Experimenter:** "I have something to show you. Look, look at this box".

The child is shown a smarties box and asked what they think the box contains.

**Experimenter:** "What do you think is inside this box?"

If the child responds with candies or smarties, then proceed to the next step. If the child does not spontaneously respond in this way, the experimenter should prompt the child by pointing to the picture of smarties
**Experimenter:** "Look at these! Do you know what these are?"

When the child responds, the experimenter should repeat the previous question
**Experimenter:** "What do you think is inside this box?"

After the child responds correctly, the experimenter opens the box to reveal crayons inside. The experimenter acts surprised to learn that the child is wrong.

**Experimenter:** "Let's open it up and see what is in here".

**Experimenter:** "Look! There are really crayons inside the box!"

Then, the experimenter puts the crayons back inside the box and closes it up again.

**Experimenter:** "Okay, what is really in the smarties box?"

The experimenter introduces a puppet.

**Experimenter:** "Look! This is Dora, and he/she has never ever seen inside this smarties box"

**Experimenter:** "What does Dora think is in the box? Smarties or crayons?" *(target question)*

**Experimenter:** "Did Dora see inside this box?" *(memory question)*

Note: To be correct, the child must accurately answer the target question (smarties) and the memory question (no).

**5) Real-Apparent Emotions Task:**

**Experimenter:** "I have something to show you".

The child is shown a piece of paper with three faces drawn on it (a happy, a neutral, and a sad face)

**Experimenter:** "Can you point to the face that is happy…okay…and sad"

The experimenter corrects the child if necessary.

**Experimenter:** "Good."

Faces are put aside.

**Experimenter:** "I'm going to tell you a story about a boy. I'm going to ask you about how the boy really feels inside and how he looks on his face. He might really feel one way inside but look a different way on his face. Or, he might really feel the same way inside as he looks on his face. I want you to tell me how he really feels inside and how he looks on his face."

Child is shown a boy puppet from the back so that the boy's facial expression can not be seen.

**Experimenter:** "This story is about Matt. Matt's friends were playing together and telling jokes. One of the older children, Rosie, told a mean joke about Matt and everyone laughed. Everyone thought it was very funny but not Matt. But, Matt didn't want the other children to see how he felt about the joke because they would call him a baby. So, Matt tried to hide how he felt."

**Experimenter:** "What did the other children do when Rosie told a mean joke about Matt?" (*First Memory Check: laughed or thought it was funny)*

**Experimenter:** "In the story, what would the other children do if they knew how Matt felt?" (*Second Memory Check: call Matt a baby or tease him)*

**Experimenter:** "So, how did Matt really feel, when everyone laughed? Did he feel happy, sad, or okay?" (Experimenter points to the three faces). *(Target feel question)*

**Experimenter:** "How did Matt try to look on his face, when everyone laughed? Did he look happy, sad, or okay?" (Experimenter points to the three faces). *(Target look question)*

Note: To be correct, or to pass this task, the child's answer to the target feel question must be more negative than his/her answer to the target look question (i.e., sad for target feel and happy or okay for target look, or okay for target feel and happy for target look).

Appendix L

Coding Form for the Theory of Mind Scale

(Chapter 3)

**THEORY OF MIND SCALE – CODING SHEET**
**(Based on Wellman & Liu, 2004)**

| **Participant #** | | | **Date Coded** | |
|---|---|---|---|---|
| **Order #** | | | **Coded by** | |

| **Diverse Desires Task** | **Circle Child's Response** | | |
|---|---|---|---|
| Which snack would you like best? *(own desire)* | carrot | cookie | |
| Which snack will Mr. Jones choose? *(other's desire)* | carrot | cookie | **Score** |
| To receive a score of 1, other's desire must be opposite own desire | | | |

| **Diverse Beliefs Task** | **Circle Child's Response** | | |
|---|---|---|---|
| Where do you think the cat is? *(own belief)* | bushes | garage | |
| Where will Linda look for her cat? *(other's belief)* | bushes | garage | **Score** |
| To receive a score of 1, other's belief must be opposite own belief | | | |

| **Knowledge Access Task** | **Circle Child's Response** | | |
|---|---|---|---|
| What do you think is inside the drawer? *(own belief)* | | | |
| Does Polly know what is in the drawer? *(target question)* | Yes | No | |
| Did Polly see inside this drawer? *(memory question)* | Yes | No | **Score** |
| To receive a score of 1, child must answer "no" to both target and memory questions | | | |

| **Contents False Belief Task** | **Circle Child's Response** | | |
|---|---|---|---|
| What do you think is inside the box? *(own belief)* | | | |
| What is really inside the Smarties box? *(own knowledge)* | Smarties | Crayons | |
| What does Dora think is in the box? *(target question)* | Smarties | Crayons | |
| Did Dora see inside this box? *(memory question)* | Yes | No | **Score** |
| To receive a score of 1, child must answer "smarties" for target question and "no" for memory question | | | |

| Real-Apparent Emotion Task | Circle Child's Response | | |
|---|---|---|---|
| What did the other children do when Rosie told a mean joke about Matt? *(memory check #1)* | | | |
| What would the other children do if they knew how Matt felt? *(memory check #2)* | | | |
| How did Matt really feel when everyone laughed?*(target feel question)* | Happy | OK | Sad |
| How did Matt try to look on his face when everyone laughed? *(target look question)* | Happy | OK | Sad |
| To receive a score of 1, child's answer for target feel question must be more negative than for the target look question | | | |

**Score**

**Total TOM Scale Score**

$\overline{\phantom{00}}$ / 5

| Real-Apparent Emotion Task | Circle Child's Response | | |
|---|---|---|---|
| What did the other children do when Rosie told a mean joke about Matt? *(memory check #1)* | | | |
| What would the other children do if they knew how Matt felt? *(memory check #2)* | | | |
| How did Matt really feel when everyone laughed?*(target feel question)* | Happy | OK | Sad |
| How did Matt try to look on his face when everyone laughed? *(target look question)* | Happy | OK | Sad |
| To receive a score of 1, child's answer for target feel question must be more negative than for the target look question | | | |

**Score**

**Total TOM Scale Score**

___
5