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Development of Theory of Mind from Ages Four to Eight

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DEVELOPMENT OF THEORY OF MIND FROM AGES FOUR TO EIGHT

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DEVELOPMENT OF THEORY OF MIND FROM AGES FOUR TO EIGHT

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An Abstract of the Thesis Presented
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The study comprised two experiments that engaged one hundred eighteen children, divided into three age groups (4-, 6-, & 8-year-olds) in competitive games with an adult designed to explore advances in children's theory of mind (TOM) beyond false-belief mastery. The game paradigms were designed so that children with an understanding of RAI (the understanding that a social partner may be observing one's behavior to gain insight into one's intentions and that one can observe the partner's behavior to gain similar insight – a proposed later development of TOM) would be more effective competitors than children who lacked such awareness. It was hypothesized that the skills required to successfully complete these games are not present in the average preschooler, but show significant development from ages 4 to 8.

Success in Experiment 1 required children to inhibit information or provide misinformation. Such abilities are considered in deception studies to be indicative of a recursive awareness of intentionality. Age trends were evident for all dependent variables, including success at the task, strategic behaviors, and

interview data. Four-year-olds were non-strategic and rarely successful, six-year-olds showed increased flexibility in their strategic behavior and were more successful, and eight-year-olds were significantly more flexible and subtle in their strategies, more successful at the task, and more likely to verbalize a recursive awareness of intention than the younger age groups.

Success in Experiment 2 required children use the behavioral cues of their opponent to guide their choices during the game. Such ability indicates awareness of the informative potential of nonverbal signals to infer the hidden intentions of a partner. Age trends emerged in children's ability to detect signals that reveal information about their partner's intentions. Eight-year-olds demonstrated significantly more awareness of the informative value of behavioral cues given by social partners than 4- and 6-year-olds and were significantly more successful at the task. Findings from both experiments suggest that there are aspects of TOM that continue to develop across middle childhood.

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INTRODUCTION

Focus of Research

The focus of this research is to determine when children use an understanding of the intentions of others to influence and make predictions about a partner's future behavior. In particular we seek to understand the emergence of a recursive awareness of intention (RAI) as a result of unfolding verbal and nonverbal cues in a social interaction. Understanding intentionality involves the ability to perceive a partner's actual intent, regardless of stated objectives, and this ability is a crucial component of a child's mature theory of mind (TOM). To successfully interact in a competitive context one must be able to: recognize that others' have goals that may differ from one's own, decode and interpret intentions, detect contingencies between verbal and nonverbal behavior and ultimate actions, and regulate expressive displays with respect to one's goals.

Historically, TOM research culminates with the preschoolers' mastery of the false-belief task (Fodor, 1992; Perner, 1991; Wellman, 1990). We argue, however, that false-belief ability is merely one building block in acquiring a mature TOM. Thus, our primary goal is to investigate what abilities continue to develop after age four. Naturalistic observation of social behavior reveals that the ability to detect social contingencies and the awareness of the intentions of others and of another's corresponding desire to gain access to one's own intentions (recursive awareness) are not fully functional in the average preschooler. Therefore, we have developed a paradigm to examine developmental changes in children's ability to detect and use contingencies to predict a partner's intentions in a game situation. Using this contingency detection paradigm, the current study will attempt to document at what age children acquire the abilities of contingency detection as it relates to a functional awareness of intentionality.

Introduction to Theory of Mind

Since Premack and Woodruff's (1978) study, which first introduced the phrase 'Theory of Mind,' there has been a great deal of research concerning the development of the understanding of mental states such as beliefs, intentions, desires, and emotions. The development of TOM is notably a lengthy process with advances in the understanding of mental states being reported from infancy to adulthood. Thus far, the majority of TOM research has concentrated on the accumulation of abilities that give rise to the understanding of false-belief between the ages of 3-5. This analysis will begin by reviewing the current understanding of TOM development that culminates in this false-belief understanding around age 4. Then, it will review what is currently known about development of TOM after age 4. Finally, it will introduce our current paradigm that attempts to achieve a fuller understanding of TOM development beyond false-belief mastery.

Hundreds of studies over the last 30 years have thoroughly explored the development of a young child's TOM before the age of four. TOM, also known as "mind-reading" (Baron-Cohen, 2005), is the understanding that other people have alternative representations of the world, which may be true or false, and which may differ from one's own. The concept of TOM provides a cohesive conceptual framework for research on cognitive and social development. However, researchers' emphasis on children only up through 4 years of age has led to an arguable deficit in the developmental literature (Lillard, 1999). A decisive shift in cognitive ability seems to emerge at age 4, and therefore researchers have been prone to treating TOM as a pass/fail phenomenon rather than as a continuously emerging skill. Researchers repeatedly conclude that at preschool age there is a qualitative shift and children newly demonstrate abilities of perspective taking, false-belief understanding, and appearance-reality distinctions. Strikingly absent in the literature is what happens after this developmental shift occurs. Researchers appear to lump 4- and 5-year-olds in with adults, ignoring the vast qualitative difference between the abilities of a child and an adult. A typical claim is: "finally, at about age 4, children begin to understand that what people think and believe, as well as what they desire, crucially affects how they behave. That is, they *acquire our adult belief-desire psychology...*" (Flavell, 1999, p.25, emphasis added).

Through monitoring of facial expression, body language, and a recursive awareness of intentionality (RAI) (knowledge that their actions will influence the actions of others, e.g., in a chess match or poker game, players must be aware that the opponent is trying to infer their intentions – and that they may be able to infer the intentions of the opponent – based on their behavior), adults can frequently predict others' strategies and intentions and recognize potential deceit. What we do not know is when and how this more advanced awareness of intentionality develops. What cues do children use to detect intentionality? What is the developmental sequence? Prerequisite skills for understanding of intentionality rely on many cognitive skills including contingency detection, an attentiveness to nonverbal social signals, a predilection to attend to faces, and an awareness of false-belief. Though many of these skills may be apparent practically from birth, their development continues into adolescence, as will be outlined in the following review.

Development of TOM up to 4 years of age has been demonstrated to be universal with achievements occurring at similar rates and in a similar sequence intra- and interculturally. Diverse cultures exhibit children passing false-belief paradigms at the same age and this achievement is always preceded by a belief-desire psychology and followed by appearance-reality understanding. Intraculturally, such as in groups of deaf, blind, or autistic children, rates of development are not always the same, but again the sequence of development remains consistent (Baron-Cohen, 2005; Wellman, 1990; Workman & Reader, 2004). TOM understanding has also been empirically demonstrated to be a gradual accumulation of advances in performance rather than a discontinuous process and seems child-driven – relatively independent of adult feedback (Flynn, 2006). Children have made much progress from their strictly egocentric frame of mind, but we argue that this is not the end of the story.

Development of Theory of Mind from birth to 4 years of age

From birth, infants demonstrate a wide range of abilities that serve as building blocks for a mature TOM. Many abilities are immediately apparent and others quickly emerge within the first few weeks of life. Infants arguably come pre-wired to be active social partners even before they have the cognitive development to support such interactions. They have visual and auditory preferences as well as automatic reflexes that integrate them into the social world and serve to ensure adequate care. Visual preferences include a preference for curved lines, high contrasts, moderate complexity, and movement – all features that are represented in the human face. They also can see best from 7-15”, about the distance to the caregiver’s face when being held or during feeding. They prefer higher pitched voices, especially their own mother’s, and they show a strong ability to learn contingencies. Bakti, Baron-Cohen, Wheelwright, Connellan, and Ahluwalia (2000) have empirically demonstrated that within the first few days infants prefer to look at faces with open eyes rather than with closed eyes (see also Pellicano & Rhodes, 2003). Within this same timeframe, they demonstrate reflexive facial imitation behaviors, showing they are attentive to the faces of others (Meltzoff & Moore, 1989). These natural preferences provide the infants with the necessary predilections that allow them to become active social partners.

Infants are quickly able to detect contingencies in the physical environment, as demonstrated by early experiments by Rovee and Rovee (1969) and Flavell (1985) (see also Millar & Weir, 1992). In such experiments, infants who can control a mobile by kicking their leg quickly learn to do so, demonstrating that they have an “understanding” that they can affect the physical world. In more resent research, Lohaus et al. (2005) have demonstrated that infants who have more sensitive caregivers (characterized by more immediate response to infant’s distress) more quickly learn contingency tasks such as the mobile task or a picture task. Also, infants whose relationships are not marked by contingent care show more irritability throughout infancy (Lemelin, Tarabulsky, & Provost, 2002).

Building upon these early contingency-detection abilities in the physical world, infants soon demonstrate expectations in the social realm. These expectations are shown by experiments such as the still-face paradigm (Rochat, 2001). Furthermore, by 3 months infants discriminate facial and vocal expressions, and are sensitive to adult gaze shift (Batki et al., 2000; Hood, Willen, & Driver, 1998). By 6 months they can follow adult gaze when it is paired with head orientation (Batki et al., 2000). In the first year of life, infants recognize the intentionality of emotional states, which they demonstrate through social referencing. Not only can they discriminate between different facial expressions, but also they are able to respond appropriately to the face-value emotional significance of the expression (Harris, 1993).

Later in the first year, as cognitive development continues, infant reflexive behaviors become more subject to effortful control. Infants continue to attend to eye gaze and they have been shown to be sensitive to adult gaze shift, looking to a target more quickly if it was previously cued by adult gaze (Hood et al., 1998).

They also prefer to look at and engage adults who imitate them (Meltzoff & Moore, 1989). As an attachment bond forms with a primary caregiver (generally the mother), the infant uses the relationship to its fullest advantage and uses mom's facial expressions as a guide to reading the outside world. They can follow gaze, demonstrate imitative learning, and use communicative gestures. The first year can be essentially characterized by the infants learning that others around them are intentional agents (Baron-Cohen, 2005; Leslie & Keeble, 1987). From birth, infants exhibit an innate learning mechanism as well as the ability to direct their own attention to maximally capitalize on environmental stimuli.

During the second year of life, development continues to proceed at this remarkable rate. Attachment to a primary caregiver has given the child a reliable source of information and children actively use it to socially reference, learn about the environment, communicate, learn perspective taking, and infer intentions. Early in the second year toddlers use eye gaze to establish joint attention and they use the face more than any other cue as they interact in the social world. When confronted with novel toys or the visual cliff paradigm, they look to the mother's face and then base their actions upon her expression. If she shows fear, they avoid the toys or the cliff, but if she shows positive, encouraging expressions, they are significantly more likely to approach the stimuli (Klinnert, 1984). From 12-18 months they respond with appropriate affect, show social referencing, and can follow eye gaze alone (Klinnert, 1984; Nelson, 1987). From 18-24 months they use eye gaze or pointing cues alone. Furthermore, during this 2^{nd} year, toddlers attempt to influence others' moods. For example, they show deliberate efforts to upset or tease others or step between warring parents (Harris, 1993).

Also during this second year, toddlers begin to show understanding that others have a different perspective than their own. Carpenter, Call, and Tomasello (2002) demonstrated this in a study where toddlers played with two toys with two experimenters. One of the experimenters left the room and a third toy was introduced. When the second experimenter returned later, she exclaimed “Wow, look at that one, can you give it to me?” without indicating a specific toy. All children brought her the third toy, demonstrating their awareness that it would be the most likely to have elicited her interested response. Children at this age can also infer an adult’s intentions even if their actions do not go to completion and they can copy their intended act, rather than the accidental outcome (Flavell, Miller, & Miller, 1993).

Year 3 brings the development of children’s awareness of other’s mental states (Wellman, 1990). They are learning about emotions, intentions, and contingency, all of which are precursors to false-belief understanding. They begin to make inferences about mental states, such as desires, based on eye-gaze, as demonstrated by tasks like Charlie and the Four Sweets. This task asks the child to predict which candy Charlie (a transparent sheet with a drawing of a face on it) wants. If the child chooses the candy that Charlie is looking at, essentially inferring his desires based on his eye gaze, then they are considered to pass the task. Children of this age also understand that desires can affect actions (Wellman’s belief-desire psychology). For example, at around 3 years of age, belief-desire tasks demonstrate that children can understand and predict other's actions based on other's desires. An average three-year-old can successfully predict that another child who has been described as liking kittens and desiring a kitten may choose a kitten for her birthday present. In other words, 3-year-olds can predict behavior and beliefs of another based on reported desires. Furthermore, 3-year-olds begin to assume that emotional experience is a result of the fit between a desire and an outcome. They begin to understand that others will be happy if they get what they want and sad if they do not (Harris, 1993).

At 3 years of age, children (especially girls) begin to understand some aspects of emotional display rules, correctly identifying when it would and would not be appropriate to express certain emotions in response to vignettes (Banerjee, 1997). Though this is a big step in development towards TOM understanding and demonstrates that three-year-olds are beginning to grasp social norms, including display rules, much of the research with this age group serves to outline what they cannot yet do. For example, three-year-olds may be able to identify when it is not appropriate to display an emotion but their ability to actually suppress an emotional display may still be lacking. Also, they may be able to engage in deception when specifically instructed, but do not demonstrate an understanding of how deceptive acts would affect another's perception (Hala, Chandler, & Fritz, 1991). In general, research to date shows that 3-year-olds have a lexical bias (Freire, Eskritt, & Lee, 2004) and are driven by salience rather than subtlety (Carlson & Moses, 2001; Carlson, Moses, & Hix, 1998**).**

In 2004, Freire et al. developed a paradigm to examine children's tendency to use eye gaze as an informative clue in cooperative and deceptive situations. In this series of experiments, children watched videos where an actor hid a toy in one of three cups. In varying conditions, the actor claimed to know the location of the toy while looking towards one of the cups, claimed ignorance to the location of the toy while looking towards one of the cups or provided contradictory verbal and eye gaze clues about the location of the toy. Three-year-olds were able to use eye gaze cues in cooperative situations (e.g., when the actor looked toward a cup while saying "the toy is there") but did not seem to garner any significance from it during deceptive situations (e.g., when the actor looked toward a cup while saying "I don't know where the toy is"). Furthermore, in contradictory conditions, three-year-olds relied on verbal cues despite repeated failure. They seem to have no appreciation for conflicting goals and do not engage in recursive thought. Though they are tuned into nonverbal cues they are unable to use them (in a similar manner that apes can follow pointing but do not seem to garner the mentalistic, attention-directing significance of such an act). Three-year-olds are unable to distinguish between know and guess, applying equal weight to both when given clues (Miscione, Marvin, & O'Brien, 1978). At 2-3 years toddlers can use eye gaze to infer mental states such as desires and thinking but only in cooperative situations (Freire, Eskritt, & Lee, 2004, see also Lee, Eskritt, Symons, & Muir, 1998). It is not until 4-5 years of age that children are sensitive to duration and frequency of eye-gaze when attempting to make further inferences about mental states (Freire et al., 2004).

While year 3 is characterized in the literature by what children are yet unable to do, year 4 brings with it an explosion of what children *can* do. Around the fourth year of life, children cross a threshold and begin to pass false-belief tasks (Wimmer & Perner, 1983), demonstrating that they are now aware that others can have beliefs that are different than their own *and* that these beliefs can be correct or incorrect. At age 4, false-belief tasks predict that children develop the understanding that others may have a different perspective than their own. False-belief understanding has been examined using such paradigms as the Sally-Ann Task. Versions of this task use two puppets, two baskets, and a marble. One puppet, Sally, hides the marble in one of the baskets and then leaves. Then, Ann moves the marble to the other basket in full view of the child. The child is then asked where Sally will look for the marble upon her return. Children who have not yet achieved false-belief understanding will predict that Sally will look in the new location, conferring their own knowledge upon her. Children who have achieved false-belief understanding, however, recognize that Sally's beliefs may differ from their own and that she is not privy to the knowledge that the marble has been moved, and thus she will look in the original location. Children begin to make this distinction around the age of 4 and it is a primary indication that they are beginning to develop TOM.

Appearance-Reality (A-R) distinctions also come on-line around the age of 4. A-R distinctions involve the ability to understand that appearance can be misleading (Woolley & Wellman, 1990). Children can be shown a sponge that is shaped like a rock and then asked what it is. Children who have not achieved A-

R understanding are likely to be misled by appearances and are unable to label the rock as a sponge even upon closer examination. Children who have not yet achieved the ability to make these distinctions are also likely to assert that white milk that has been covered by a green filter has, in fact, turned green. They will avow that if they were to look behind the filter or if the filter were to be removed the milk would remain green. Older children, who have achieved A-R understanding, are able to express that the milk only appears to be green, but in reality, the milk is still white (Flavell, 1985).

One of the key implications and extensions of achieving this A-R understanding is the awareness that expressive behaviors may not always match inner feelings (Flavell, 2000). This awareness is key for social intelligence and must be realized to be a strategically interactive partner in the social world. Achieving the ability to distinguish appearance from reality allows for emotional dissemblance (the ability to hide or conceal one's true motives, feelings, or beliefs), is required to use cultural display rules (modification of facial expression to meet social expectations) (Ekman & Friesen, 1971), and allows for tactical deception (the ability to misrepresent your intentions to attain strategic advantage in a competitive situation). However, to successfully use tactical deception and decipher displays, one must be able to predict the intentions behind the behaviors of others. Though this understanding is crucial to be a competent opponent in the social world, it is important to note that such an understanding is very fragile at this age and continues to develop well into late childhood and adolescence.

By 4 years of age, children are aware that others have unique thoughts and beliefs, but they are still unskilled at causing false beliefs through deception or trickery. As demonstrated in LaFreniere's (1988) hide-the-bear task where children were asked to hide a stuffed bear in one of three locations and to not divulge the location to a 'hunter', 4-year-old children demonstrated an attempt to suppress information about the bear's location, but they were still unable to stifle telling cues, such as eye gaze, orientation, or other actions (e.g., giggles), remaining rather oblivious to what cues a social opponent would use.

Baron-Cohen (2005) summarizes the development of skills leading to TOM development in his 1994 model of mindreading (see Figure 1):

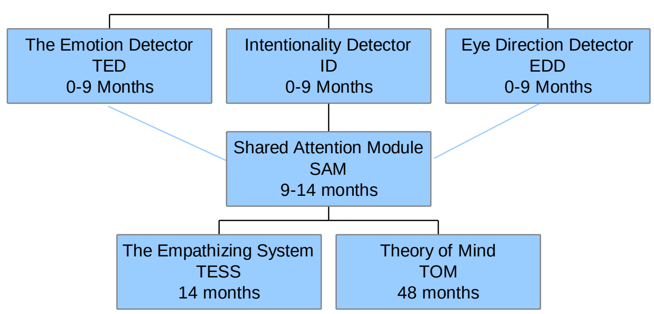

Figure 1. Baron-Cohen's Model of TOM Development

From 0-9 months, Baron-Cohen's model proposes The Emotion Detector (i.e., discrimination of basic emotions), the Intentionality Detector (i.e., basic understanding that actions have goals), and an Eye Direction Detector (i.e., ability to use eye gaze). At 9 months, these skills are coordinated and feed into a Shared Attention Mechanism that allows for organized joint attention between the child and another. At 14 months, The Empathizing System keys into detecting emotional states and allows for appropriate empathetic reactions to another's emotional state. And, finally, the TOM mechanism, as discussed earlier, is proposed to be evident at 4 years of age.

According to this time-line of development, by 4 years of age, children should have all the skills necessary to infer others' intentions. According to the five postulates set forth by previous research, children now understand that "the mind (1) exists, (2) has connections to the physical world, (3) is separate from and differs from the physical world, (4) can represent objects and events accurately or inaccurately, and (5) actively mediates the interpretation of reality and the emotion experienced" (Flavell, Miller, & Miller, 1993, p.101). With these achievements, year 4 seems to be held as the pinnacle of development in TOM circles, but even a naïve observer can see that the mind-reading abilities of a 4-year-old are very different than those of an adult. Certainly there are further developments that lie under the surface yet to be explored. Just as cognitive development is not completed at the preschool age even with advances in memory and attention, understanding of the social world is similarly underdeveloped. Researchers who implicitly claim that TOM is complete at the preschool age neglect developments in abilities that continue to accrue over middle childhood. For example, as demonstrated by several researchers, RAI, or the understanding that the cues one provides will influence the beliefs and actions of those receiving them, is virtually absent in children younger than age 5. "In fact, understanding recursive thought would be a good candidate for a sixth postulate for a TOM in late childhood or early adolescence" (Flavell, Miller, & Miller 1993, p. 218).

Development of Theory of Mind beyond 4 years of age

Some research has attempted to bridge the gap between the abilities of an older child/adult and those of a preschooler. Emotional understanding has been laid out on an 11-year time-line ranging from the mere recognition of emotions to understanding moral emotions (Pons & Harris, 2005; Pons, Harris, & DeRosnay, 2004). Tactical deception and recursive awareness abilities have been investigated throughout the first 8 years (LaFreniere, 1988; Schultz & Cloghesy, 1981). Research with deaf, blind, and autistic children, furthermore, examines TOM development into later childhood. Investigation into what skills children use to detect intention, infer truth, and mislead others is beginning to emerge as well. For example, research has examined when children begin to use nonverbal signals to interpret behavior and when children can use nonverbal signals to mislead others. Freire, Eskritt, and Lee (2004) found that in a deceptive task, 5-year-olds interpreted eye gaze as more informative and revealing than a misleading verbal cue. Three-year-olds, though able to detect and follow the experimenter's gaze, as demonstrated in a cooperative task, were more likely to rely on verbal information rather than the referential and more truthful eye-gaze cue when the two were in opposition. Thus, it seems that 4-5-year-olds are starting to attend to informative nonverbal cues to read the intentions of others in deceptive situations while 3-years-olds are not yet savvy enough to read underlying intentions to behavior. So, though children can follow eye gaze and detect contingencies from infancy, achieve joint attention by 12 months, and infer mental states by 3 years, they are still unable to successfully decode signals when confronted with deceptive information. By 5 years of age, however, children are beginning to use eye gaze cues to infer intentions, even in the presence of contradictory verbal cues. This study demonstrates that ability to detect intentions has begun in the preschool years though "the detection of deception from such cues may emerge beyond the preschool years and develop well into adolescence" (Freire et al., 2004, p. 1102).

After 4 years of age we continue to see increases in not only TOM, but also perspective taking (a skill many adults still need to hone), recursive awareness (which probably epitomizes the adolescent social circle), interpersonal skills, goals, strategies, understanding of the implications of the actions of others, and appearance-reality differences. Around 5-6 years of age, those skills that were demonstrated as a 4-year-old are solidifying and becoming less fragile. Certainly helped along by ever increasing language skills and social experience, children are beginning to be able to make appearance-reality distinctions not only in the physical world but also in the emotional world. They begin to recognize discrepancy between real and displayed emotion and are able to enact cultural display rules in more arousing situations (Pons, Harris, & DeRosnay, 2004). They are also becoming aware of tactical deception strategies, even if they are not able to successfully carry them out. In LaFreniere's (1988) hide-the-bear task, 5-6-year-olds were more able to control and inhibit nonverbal cues, though they still did not generally spontaneously produce misleading cues, thereby demonstrating a continued lack of mature recursive awareness. In a card-playing paradigm that will be discussed more fully later, Shultz and Cloghesy (1981) required children to be receptive to and to initiate strategies to win cards. Though as early as 5 years of age, children demonstrated a budding awareness of deceptive strategies, they were better at retaliating against them than producing them. These children are developing greater cognitive and behavioral control and are on the cusp of being able to consider multiple factors at the same time.

In Bering and Parker's (2006) study examining attribution of intention to an invisible agent, children were told that an invisible 'Princess Alice' was in the room and was going to try to help them be successful at a guessing task by telling them if they pick the wrong box. Children were asked to make decisions (choosing one of two boxes) and then a hidden examiner used a remote to cause a lamp to flash or a picture to fall. Though children as young as 5 years of age identified these occurrences as produced by Princess Alice, they did not use such antics as informative for their decision-making in the task at hand. Three-year-olds attributed occurrences to purely physical causes (e.g., the picture must not have been hung very well). Five-year-olds attributed them to Princess Alice but did not take them to be signs of her intentionally trying to communicate with them to help them with their guess. It was not until 7 years of age that children were able to use such antics as a source of information to help guide their decisions.

By adulthood most individuals have a mature TOM and are adept at using eye gaze, tone, inflection, and other nonverbal cues to garner a fuller understanding of the intentions behind mere verbal communication. Freire et al. (2004) assert that adults regularly use eye-gaze to detect and infer deception and are highly skilled at recursive awareness. It has even been found that eye-direction is so salient that it triggers automatic shifts in visual attention, even when participants are instructed to ignore it or when it is a detriment to performance (Posner, 1980). Adults have come a long way in their social abilities, helped along by cognitive development and social experience. It is apparent that progress takes place, but more research is needed to fully understand how and when changes occur.

The development of a child’s ability to detect signals of intention, especially those that indicate purposefully misleading intentions, is only half of the story. As social participants, children also have the opportunity to produce their own misleading intentional cues to achieve their own social goals. This ability of tactical deception begins to emerge around the preschool age and can be seen in children’s attempts to trick their peers, avoid punishment, acquire more time to play, etc. Tactical deception, or the ability to purposefully conceal one’s intentions, misrepresent one’s intentions, or successfully read the intentions of others lays a foundation for securing strategic advantage during an adversarial encounter in the social world and is a key to the development of social intelligence.

Between 5-6 years of age, children demonstrate the ability to use nonverbal cues to infer intentions even in light of contradictory verbal cues. However, they are unable to use this understanding to successfully mislead an adult who was trying to detect deception. In Feldman, Jenkins, and Popoola's (1979) study, children were asked to pretend they liked a drink, regardless of whether it tasted good or bad and then adults were asked to determine which drinks the children actually liked and which they were only pretending to like. First graders were generally unsuccessful at covering up their negative opinion of the drink when judged by adults. Seventh graders were more able to cover up their negative opinion, though they were more likely to inhibit any response, whereas college students were also able to deceive judges, though their strategies generally involved producing an alternative expressive response rather than merely inhibiting the true response. Therefore, it appears that deception strategies evolve from mere inhibition of expressive cues to increasingly deceptive production of alternate expressions to enhance deceptive displays.

In a task examining tactical deception in which children were instructed to hide a small bear from a "hunter", LaFreniere (1988) found that children younger than 4 were always unsuccessful in attempts to fool the adult when asked about the bear's location. Furthermore, five and six-year-olds were only very occasionally successful. It wasn't until 8 years of age that children could use tactical deception to fool an adult significantly more often. The youngest group attempted to inhibit information, but leaked clues by glancing at the bear's location, using a predictable hiding strategy, or telling the adult where the bear was. Five- and 6-year-olds were more successful at inhibiting information but not yet skilled at conveying false information in a stimulating situation. Eight-year-olds not only were more successful in inhibiting information, but they were the only group that also produced information to suggest false intentions. This production of false cues demonstrates an ability of recursive awareness — that the cues one provides will influence the beliefs and actions of those receiving them. To successfully use recursive awareness, one must not only realize what cues an opponent will use to infer intention, but also must modify such cues in a convincing manner.

Schultz and Cloghesy (1981) designed a study that looked at children's ability to perceive intentions as well as their ability to produce successful misleading intentional cues. These researchers developed a guessing game paradigm to investigate when awareness of intentionality develops. The game provided a "situation where it was advantageous for the child to engage in strategic actions" (Schultz & Cloghesy, 1981, p.466) to win the game. In the game, one player attempted to guess the color of the next card in a regular deck of playing cards based upon a hint given by the other player. In some conditions the examiner gave hints and in others, the child provided the hint. The examiner would always start by playing straight (pointing to the correct card or guessing the card the child pointed to) and after the child won four straight cards, he would switch to the deceptive strategy. To be successful, children needed to strategically disguise their intentions by pointing to the incorrect cards, guessing the color opposite to that pointed to by the examiner, and switching strategies when appropriate. These actions would reveal that the child knew that the examiner was attempting to gain access to the child's intentions and that they needed to change their behavior to compete effectively. They found that such recursive strategies are sometimes employed by 5-year-olds but never by 3-year-olds and performance continued to improve from ages 7 to 9. It was also found that "children appeared to be better at retaliating against deceptive strategies than at initiating them" (Schultz & Cloghesy, 1981, p.465).

Based upon the paradigm developed by Schultz and Cloghesy (1981), LaFreniere (1988) developed a modified version of this game to examine how well children can use contingent expressive cues to detect ongoing deception. Children from 4–8 were instructed to guess the color of the next card based on the cues provided by the examiner. However, in this modification, the truthfulness of the cue was contingent upon the facial expression of the examiner providing it. In one condition, the experimenter would smile whenever giving a false clue and keep a poker face when giving an honest clue. These facial cues were reversed in the second condition. As expected, preschoolers were rarely successful in solving any condition of the contingency task, taking any cue as an honest signal. Older children solved the contingency more frequently, with 50% scoring above chance. Interestingly, there was a significant effect of condition for the older group. Three times as many children solved the problem when deception was paired with a smile than when paired with a neutral expression. They interpreted the "sneaky grin" on the examiner's face as linked to on-going deception. These results beg the question of what nonverbal signals children use to detect intentionality (are some cues more illustrative than others?) and what signals do they use or attempt to suppress in order to influence the behavior of others? We will attempt to find answers to both questions as we seek to investigate the development of recursive awareness in the current study.

Recursive awareness provides the first indication that children are actively engaged in the thought processes of others and are aware of how their own responses can be used and manipulated by themselves and by social partners. Reviewed research shows that from age 7–9 children show an increase in recursive awareness abilities and are finally able to more productively use strategies to manipulate competitive social exchanges. In Shultz and Cloghesy's (1981) card playing paradigm, these 7–9-year-olds were able to use recursive strategies to win cards, to mislead, and to preemptively strike against the adult examiner. These children were also savvier at using tactical deception strategies. In LaFreniere's (1988) hide-the-bear task, not only could they inhibit leading nonverbal cues, but also they could produce deceptive cues to actively mislead their opponent, clearly demonstrating their grasp on what cues their opponent was relying on to make predictions.

Though skills increase from 7–9 years of age, it is not until around year 11 that social understanding becomes increasingly more adult-like. At this age children not only can engage in recursive strategies but also can verbally discuss strategies and demonstrate an awareness of how their actions may be perceived by another (Schultz & Cloghesy, 1981). Around this point in maturation, these children also begin to demonstrate right hemisphere dominant activation during

TOM and emotional understanding tasks, similar to an adult (Workman, Chilvers, Yeomans, & Taylor, 2006). Such specialization may be necessary to fully develop social awareness, social cognition, and true recursive awareness. This evidence supports Flavell, Miller, and Miller's (1993) assertion that the development of recursive awareness may reflect TOM development in adolescence.

True recursive awareness is a developmental step beyond basic TOM understanding, when TOM is characterized by false-belief mastery. For recursive awareness, not only must children have an awareness of the beliefs and thoughts of another, but they also must have a conception that the other has a similar awareness of their own thoughts. So, not only must children be capable of taking into account their partner's perspective, but also children must be capable of taking into account their partner-taking-into-account-the-child's perspective. In this manner, it logically follows that children would be able to produce misleading intentional cues (by merely taking into account what their partner will believe) before they will be able to decode such cues from another (which would require taking into account the partner-taking-into-account the child's own beliefs) (LaFreniere, 2000). Such recursion quickly becomes convoluted (I think that he thinks that I think that he will think that I…), yet in day-to-day encounters adults routinely decode elaborate intentions through appraisal of verbal and nonverbal signals as they navigate the social world. Such ability is the culmination of many prior developments. Understanding physical and social contingencies, facial expressions, verbal and nonverbal cues, underlying intentions, TOM, and the implications of different behaviors within a specific social context are the prerequisites for the recursive behavior that is ubiquitous in human culture. A four-year-old’s basic understanding of false-belief is very lacking in revealing a mature social understanding. Based on this, there is a call for examination of later developments before we can claim to truly understand the development of social intelligence.

One of the obstacles in studying TOM is that it is a uniquely human trait. Though extensive time and effort has been put into investigating whether or not chimpanzees have a TOM (Povenelli & Eddy, 1996; Premack & Woodruff, 1978; Tomasello & Call, 1997; see also Call & Tomasello, 2008), to date the general consensus remains that chimpanzees have a behavioristic rather than mentalistic concept of others, (i.e., chimpanzees learn and respond to the outward behavior of others without making attributions about underlying mental motivations and intentions). Therefore, study must be relegated to humans only and to the ethical bounds inherent to such study. We can garner some insight into functioning without TOM through examination of populations where it is hypothesized to be limited or absent (e.g, as in cases of autism) (Campbell et al., 2006) or by looking to cases where it is thought to be enhanced, at least when measured by mental age (William’s syndrome). Other examinations of TOM and its development and implications rely on creative methodology and careful control.

Naturalistic observation of preschoolers has revealed that children begin to use egocentric (and unsuccessful) deception attempts as a means of avoiding trouble, maintaining social cohesion, and achieving social goals very early on in life (LaFreniere, 1988). These observations of children's naturally occurring behavior in situ, while illuminating in some respects, have led to an accumulation of inconclusive anecdotes that do not permit firm inferences about the cognitive abilities of children at different ages (Byrne & Whiten, 1988). Both developmental psychologists and primatologists have questioned whether the basis of behavior is anything more than mere behavioral conditioning (Povinelli & Eddy, 1996). Therefore, the current study uses classical experimental methods to examine children's mentalistic understanding of mental states at different ages. A game-playing situation is used during which children's natural competitive strategies can be observed as well as their ability to perceive the strategies of the examiner who "leaks" telltale signs of hidden intentions (i.e., glancing and smiling behavior).

Development can be conceptualized as the convergence of evolved adaptations, biological propensities, individual characteristics, and sociocultural experiences. Study has already shown that TOM development is impacted by biological propensities (e.g., through behavioral genetics research (Iarocci, Yager, & Elfers, 2007) and through cross cultural research demonstrating similar developmental timelines and sequences through different cultures) (Liu, Wellman, Tardif, & Sabbagh, 2008), and sociocultural experiences (e.g., a large family or experience with parents, siblings and peers) (Hughes, Jaffee, Happe, Taylor, Caspi, & Moffitt, 2005). As cognitive development progresses and individuals are able to consider multiple perspectives, it is necessary to look at individual differences that impact TOM development at older, more socially functional levels. Although TOM can be studied through deception tasks, in the social world it also functions to increase social cohesiveness, communication, perspective taking, and to facilitate the accomplishment of goals. Understanding of the individual characteristics and abilities that lead people to excel in such areas could have positive implications for training programs and supported development. Important aspects to consider would be one's ability to react selectively to unique individuals, situations, and in different types of relationships. One must also have active coping strategies to regulate arousal in confrontational situations, and one must monitor and control behavior to fit the ever-changing situation. Finally, to be able to respond and act persuasively, one must have the belief in his/her own self-efficacy of manipulating the actions and thoughts of others. Examination of characteristics, strategies, and goals of such individuals would illuminate what TOM characteristics are necessary to develop to be exceptionally influential.

Diplomacy, persuasion, and empathy, as well as deception, all rely on having the ability to sensitively understand and take into consideration the perspective of those around you — whether it be peers in a preschool classroom, crowds in adolescence, romantic partners in adulthood, co-workers in an office, or different cultural, racial, or religious groups around the world. While the heralded false-belief understanding demonstrated in a puppet-task by a 4-year-old marks the beginning of the development of such skills, there is a long road that must be traveled before a child can successfully navigate the broader human world. How and when these skills are achieved and in what situations such skills are applied or neglected will determine how successfully one can interact in a complex social environment.

Recent research shows that a mature understanding of the social world is not present with acquisition of TOM as historically conceptualized. Further research plotting the development of recursive awareness is vital. Therefore, the current study seeks to determine developmental differences between encoding and decoding signals that reveal intention, to assess the age when children can use contingent facial expressions to detect intentions, to examine if different facial expressions facilitate or hinder understanding of intentions, to observe whether children learn some contingencies earlier than others, and to assess when and by means a child may seek to influence the beliefs of others.

The Present Study's Basic Design

In the present study, we proposed that recursive awareness of intentionality (RAI) is not present during young childhood, even after the age of traditional false-belief mastery. Using a modified version of Schultz and Cloghesy's (1981) card playing paradigm, three age groups were given the opportunity to use an understanding of RAI (the understanding that the partner is observing one's behavior in an attempt to gain insight into one's intentions and that one can observe the partner's behavior to gain similar insight) to compete more effectively in competitive game situations. The original game (1981) was modified to allow the children to attempt to control a situation in which a RAI would make them more effective competitors. We are primarily interested in developmental differences; therefore, hypotheses were formulated with respect to age. No sex differences were predicted for this experiment.

The present study engaged 4-, 6-, and 8-year-olds in a guessing game paradigm designed to examine age differences in children's ability to influence and respond to the behavior of an adult partner. The game was played with a deck of cards turned face down. In Experiment 1, children were asked to look at the top card in the deck and then the examiner would attempt to guess its color based on a pointing cue from the child as well as by observing any nonverbal (or verbal) clues that the child emitted (e.g., eye-gaze, head orientation, verbalization of card color). Success required that the child be able to identify and suppress behaviors that would reveal information to the adult as well as to potentially provide false cues to mislead the examiner. In Experiment 2, the situation was reversed. Children were asked to guess the color of the card based on a hint by the adult. In Experiment 2, the veracity of the adult's hints was contingent upon her facial expression. Success required that children be able to recognize the informative value of the nonverbal behavior to make accurate choices throughout the trials. Experiment 1 will be reported in its entirety and then Experiment 2 will be presented. Finally a general discussion integrating the findings will conclude the thesis.

Experiment 1

Dependent Variables

Children were rated on how many cards they won during the game. Coders also rated the children's behaviors on a series of behavioral categories (explicit revelation, accidental revelation, salient hiding attempts, false information and number of changes in pointing strategy). Children were also categorized based on follow-up interview data that were organized to verbally assess their level of RAI.

Developmental Hypotheses

According to previous research there are systematic developmental advances in young children's deployment of tactical strategies to win a competitive game paradigm, with predominant strategies characteristic of each of the age groups examined (LaFreniere, 1988; Schultz & Cloghesy, 1981). We believe that advances result from an emerging understanding of RAI (the understanding that the partner is observing one's behavior in an attempt to gain insight into one's intentions and that one can observe the partner's behavior to gain similar insight). The current paradigm was created based on this previous research to place children in a scenario where RAI is necessary for successful completion of the experimental task. Based on the systematic developmental advances previously found, the following hypotheses were made with respect to age:

1. Eight-year-olds were predicted to demonstrate a more developed RAI and thus would be significantly more successful at the current game paradigm than would 6-year-olds, who would be significantly more successful than 4-year-olds.
2. Eight-year-olds were predicted to demonstrate the understanding that their behavior may provide information to their partner. Eight-year-olds were expected

to use this understanding to monitor their own behavior enabling them to reveal significantly less information than six-year-olds, who would reveal significantly less information than 4-year-olds.

3. Eight-year-olds were predicted to demonstrate an understanding that they can modify their own behavior to successfully mislead their partner and were expected to demonstrate more attempts at hiding information than 6-year-olds who would demonstrate more hiding attempts than 4-year-olds.

4. Eight-year-olds were predicted to actively fabricate false cues to more effectively mislead their opponent significantly more often than 6-year-olds who would produce more false cues than 4-year-olds.

5. Eight-year-olds' verbal reports during the interview were predicted to demonstrate a greater understanding of RAI than 6-year-olds who were predicted demonstrate a more developed understanding than 4-year-olds.

Chapter II

METHODS EXPERIMENT 1

Experiment 1: Encoding

Participants

One hundred and eighteen predominantly white, middle-class children (36 4-year-olds (M = 52.4 months, SD = 5.8, and range = 41-65), 41 each of 6- (M = 70.3 months, SD = 3.7, and range = 64-77) and 8-year-olds (M = 95.3 months, SD = 3.8, and range = 89-103)) were recruited from local preschool and elementary schools (See Table 1). Participants were from predominantly white, middle- and working-class families living in small Maine communities.

Table 1. Age and Sex of Participants

Age	Males	Females	Total
4-year-olds	22	14	36
6-year-olds	22	19	41
8-year-olds	20	21	41
Total	64	54	118

Informed Consent

Local superintendents, principals, and teachers were contacted and invited to participate in a study that would inform us about the development of children's theory of mind (TOM) after age 4. Once classrooms had district permission to participate, letters were sent home to parents informing them about the nature of the study and asking for their permission for their children to participate. Parents were told that children would be videotaped to ensure that behaviors could be coded later, and that videotapes would remain confidential. Parents were asked to sign an informed consent form that described the nature of the study (see Appendix A). In addition, each child was invited to participate at the beginning of the experimental session and was allowed to withdraw at any time (see Appendix B). Only one child (in the 4-year-old age group) declined to participate. The child agreed to accompany the examiner to the examination room but then refused to respond to any questions, prompts, or stimuli and thus was excluded from the analysis.

Materials

A video recorder with a zoom lens was placed unobtrusively in the testing room and was used to videotape the children's behavior. Children were informed that they were being videotaped and they quickly acclimated to the camera in the room.

Procedures

We were interested in when children develop an understanding of recursive awareness of intention (RAI) and attempt to use this understanding to influence social interactions. First, children were introduced to a simple guessing game in order to establish basic ability to detect simple contingencies (see Appendix B for all instructions given to child). This introductory task not only provided baseline data, but also served to orient the child to the exam room and testing stimuli. The task involved two stacks of ordinary playing cards, lying face down on the table. The child was instructed to guess the color of the next card (either red or black), alternating between decks. The deck on the right was made up of all black cards and the deck on the left was all red, creating a simple contingency paradigm. It was expected that children of all ages would be able to quickly grasp the contingency between deck position and color and shortly be able to make accurate predictions. The examiner introduced the task:

> This is a guessing game. The game is played with a deck of cards. Each card is red or black (*show the card as the color is named*). The game is to guess the color of the next card in these stacks (*point to the two stacks*). What color do you think this card is? What about his one? (*Alternate between decks until the child is able to successfully "guess" the color 6 consecutive times*). You did great! Let's try the next game!

Once the child demonstrated the ability to detect the contingency, the decks were shuffled together and the second part of the Experiment 1 began. For Part 2 of Experiment 1, children were asked to individually engage in a guessing game with the examiner using a deck of 20 cards to determine at what age and by what means a child demonstrates intentions and ability to successfully mislead others in a competitive situation. The shuffled deck was placed face down in the center of a table with a red card placed face up to the left of the deck and a black card face up to the right. The child was asked to look at the next card in the deck and then point to either the red or the black card as a clue for the examiner, whose task it was to guess the color of the hidden card. If the child did not spontaneously point to one of the cards, he/she was reminded to point to give the examiner a hint. If the examiner guessed correctly she won the card, if she guessed incorrectly, the child won the card. The object of the game was to win as many cards as possible. The competitive nature of the game was stressed to each child. The examiner attempted to guess the color by reading the child's social or nonverbal signals, facial expression, eye gaze, etc. Observation of the child's behaviors, success at deception (quantified as how many cards he/she won), and responses to a follow-up interview were used to determine when children develop an awareness of which cues their partner is using to gain information as well as when children are able to inhibit such cues or to provide false cues to mislead their partner.

Once the child demonstrated an understanding of his/her role, this second part of the experiment began. The examiner introduced Part 2:

> Next you get to have a turn looking at the cards and I will try to guess what the color is! You will look at the card and then point to either the red card or the black card to give me a hint. If I guess right, then I win the card. If you trick me and I guess wrong, then you win the card. Remember; try to win as many cards as you can! Okay?

Trials consisted of 20 cards and interactions were videotaped for later analysis of the behavior of the child who was playing the role of the clue-giver. Eye gaze, verbal and nonverbal signals (i.e., consistently orienting towards the correct/incorrect card), and facial expressions were observed as well as the child's overall success at deception (quantified by how many cards he/she won). These data determined how able the child was at hiding his/her true intentions and conveying false ones and provided insight into when and by what means a child can demonstrate intentions to successfully mislead others. Such ability indicates a developing recursive awareness where children demonstrate they understand what cues their opponent may be using to make accurate predictions as well as the ability to manipulate cues convincingly. The number of cards a child won was recorded and children were also interviewed following the game to assess what strategies, if any, that they used to attempt to prevent their opponent from guessing the correct color (see Interview Template 1, Appendix C).

Internal Consistency Reliability for Behavior Coding

After completing all testing, research assistants coded the videotapes for behaviors that revealed, inhibited, or fabricated information. Three coders met with the primary examiner weekly to establish a list of target behaviors of interest and to streamline a rating form to be used with each video. Once all coders were trained, they coded the first 20 videos independently. Based on these first 20 video ratings, inter-rater reliability checks demonstrated high reliability among all coders. All raters were significantly correlated, *Spearman's rho* = 0.9, p < .001. Furthermore, cross tabs analysis revealed an average *Kappa* = .6, p< .001. Once inter-rater reliability was attained, raters scored the remaining videos independently. Following these independent ratings, each video was viewed again as a group and any discrepancies among the three raters' scores were resolved. In this manner a final behavioral record was produced for each child. (See Appendix D: Coding of Behavior Template; Appendix E: Behavior Coding Instructions)

Behaviors of interest

Examination of videos of the children's performances allowed us to examine several categories of behaviors that were of special interest as we attempted to outline differences that may account for the differences in children's success levels at manipulating an adult's behavior. We were interested in, 1) behaviors that revealed information to the examiner, divided into *explicit revelations* of information (indicating that the child was not attempting to hide information) and *accidental revelations* of information (indicating a lack of awareness of what behaviors may be used by a partner and thus need to be controlled), 2) behavior that demonstrated an attempt to *hide* information (visible attempts at suppressing information), and finally, 3) behaviors that were indicative of fabricating information to actively mislead the opponent, divided into *false cues* (attempting to give misinformation to mislead the guesser) and number of changes in *pointing strategy* (i.e., pointing sometimes to the correct color and other times to the incorrect color). Each of these types of behaviors was of special interest because they each reveal something about the child's level of recursive awareness.

Explicit revelations of information are relatively uninformative because we cannot conclusively determine the child's goals (e.g., Do they understand the task? Are they motivated to win the cards?). Accidental revelations of information are more interesting. When the child is actively attempting to mislead the adult and accidentally gives away information, we can conclude that the child has an immature understanding of what behavioral cues the adult is using to gain insight. The presence of visible attempts to hide information is also interesting. If children make a visible effort to hide possible sources of information from the adult, they are indicating that they are aware of what behaviors an adult may draw information from and realize that they have the ability to conceal such cues. Provision of false information is interesting as well because it demonstrates that children recognize that their partner is using particular cues to garner information and the children realize they have the potential to manipulate the adult's beliefs. Finally, the ability to switch flexibly between pointing strategies shows a more subtle understanding of what cues the adult is drawing information from. Research assistants coded all of the videos, summing how many of each type of behavior was present for each child during Experiment 1

<u>Interview Data</u>

In addition to pass/fail information and behavioral analysis, we also analyzed the children based on follow-up interview data. Based on verbal reports elicited by interview questions immediately following the task the examiner categorized the children into one of three groups: those providing 1) no indication of RAI (e.g., shrugging, no attempts to influence adult's guess in a strategic manner), 2) incomplete indication of RAI (consistent strategy or inability to explain strategy, e.g., "I tried to trick you. I pointed to the wrong one but you guessed it anyway."), or 3) evidence of conclusive understanding of RAI (e.g., "I looked at that one so you would think it was that color, but really it was the other one and I knew you would think I would do that again so I didn't."). Children in this final group frequently used vocabulary that revealed insight into the expected thoughts or expectations of the partner.

Chapter III

RESULTS EXPERIMENT 1

Analysis Strategy

A number of analytic strategies were used to examine developmental trends in the dependent variables of primary interest. General Linear Modeling using a Poisson Regression Analysis, generating *chi-square* (χ^2) and *p*-values was employed to assess age differences for probability of reaching success criteria as well as to assess age differences in behavioral strategies and verbal report (Cameron & Trivedi, 1998). These values were corrected using the SIDAK post hoc test, which acts as a protection factor for inflated Type 1 error rates when examining all pairwise combinations (Gravetter & Wallnau, 2000). The Poisson Regression Analysis was used because we collected count data that were non-continuous and we did not expect that the behavioral data would be distributed normally. This expectation was confirmed when data demonstrated skew on an exploratory Q-Q plot. Preliminary analyses will be presented first, followed by analyses specific to each hypothesis set forth by this study. Analyses of differences by age are of primary interest, though sex differences will be noted where applicable. For ease of interpretation, figures are predominantly used throughout the text. For additional tables, see Appendix H.

Simple contingency detection results

All children were able to correctly detect the simple contingency when asked to guess the color of the next card when stacks were segregated by color.

This simple preliminary task was continued until a child guessed correctly 6 consecutive times. The majority of children achieved this goal within the first 6-8 cards. The largest number of trials necessary for any child was 10 cards. Children of all ages were very quick and accurate in identifying the contingency inherent in the task design.

Sex Differences

Before addressing individual hypotheses that were formulated with respect to age, sex differences were analyzed and these preliminary analyses revealed no significant effect of sex on overall success at the task for Experiment 1, *Wald* $\chi^2(1, N=118) = .002$, $p = .96$ (see Appendix H, Table H.1.). Analysis of behavioral data revealed significance sex differences in a few of the behavioral categories studied. These differences will be discussed in more detail where applicable (see Table H.2.). Because preliminary analyses did not reveal overall significant effects for sex or age by sex interaction effects, data for boys and girls were collapsed together for the remaining analyses.

Success Criteria Justification

Children were recorded as being successful at the task if they were able to reduce the adult's overall chance of guessing correctly to at or below the minimum expected by chance (i.e., ≤ 13). Fewer than 13 correct guesses likely represented chance responding due to binomial probability estimates of performance by chance alone. It was assumed that if the adult was able to choose correctly 13 or more out of the possible 20 times, then she was no longer making random guesses (p < .07) and instead was garnering information from the child's behavior to guide her choices.

Hypothesis 1: Age Differences in Success Rate

It was predicted that 8-year-olds would demonstrate greater understanding of recursive awareness of intentionality (RAI) and thus would be significantly more successful at the current game paradigm than would 6-year-olds, who would be significantly more successful than 4-year-olds. Success was quantified as the child reducing an adult's chance of guessing correctly back to chance levels (i.e., <13 of the possible 20 cards, $p < .05$). Based on our analysis, there were significant differences in success rate by age, *Wald* $\chi^2(2, N = 118) = 10.2$, $p = .001$. A SIDAK post hoc analysis revealed significant improvement with age for each of the three age groups studied. (See Figure 2 and Table H.3.).

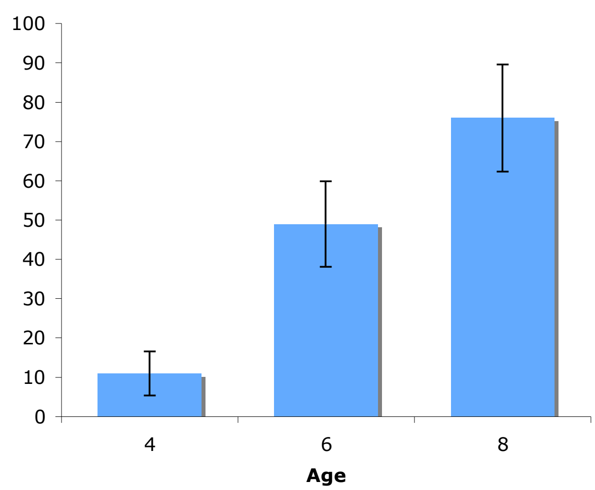

Figure 2. Percentage of Children Reaching Success Criterion by Age.
Vertical lines depict standard error of the means. All pairwise comparisons are significant to at least $p < .02$.

Overview of Hypotheses 2-4: Behaviors of Interest

A simple count was conducted to calculate the number of children who demonstrated each of the behaviors of interest. Also, to explore how frequently children demonstrated each behavior, we calculated how many children in each age group used each of the behaviors as their predominant strategy (see Table H.4.). To be a predominant strategy, children had to demonstrate behaviors that fell into the category on at least 50% of the game trials. Children who did not demonstrate a particular behavioral strategy on at least 50% of the trials were recorded as having a 'mixed strategy' meaning that they sometimes revealed information, sometimes hid information, and/or sometimes gave false cues.

The most salient descriptive differences in the raw data were apparent within three behavioral categories: explicit revelation of information, attempts at hiding information, and number of changes in pointing strategy. As shown in Table H.4., 4-year-olds explicitly revealed information more often than the older age groups with 78% of 4-year-olds revealing information at some point during the game and 44% revealing information on more than 50% of the trials. In contrast only 2% of 6-year-olds explicitly revealed information on more than 50% of the trials and no 8-year-olds revealed information as a predominant strategy. Six-year-olds were the most likely to attempt to hide information from an opponent, with 10% of 6-year-olds using hiding as their predominant strategy compared to only 3% of 4-year-olds and 0% of 8-year-olds. On the other hand, 8-year-olds tended to rely on flexibly switching their pointing strategy when providing clues, with 68% of 8-year-olds using changing their pointing strategy as their predominant strategy, 51% of 6-year-olds and only 11% of 4-year-olds. No child exhibited accidental revelations or false cues as a predominant strategy. Further analyses of each behavior of interest will be reported with respect to the posed hypotheses in the following sections.

Hypothesis 2: Age Trends in Revelation Behaviors

Explicit Revelations

When behaviors of interest were examined using the Poisson Regression Analysis, we found significant age differences for explicit revelation behaviors for the three age groups examined as was hypothesized, *Wald* $\chi^2(2, N = 118) = 329.8$, $p < .001$. A SIDAK post hoc analysis revealed significant differences between each of the three age groups examined. Four-year-olds explicitly revealed information (showed the card purposefully and/or verbalized the correct answer) significantly more than 6-year-olds, who revealed more than 8-year-olds. (see Figure 3). Statistical analysis results for all behaviors of interest are summarized in Table 2.

Table 2. Mean (SD) Number of Behaviors of Interest by Age

Age (years)	N	Explicit Reveal	Accidental Reveal	Hiding Behaviors	False Cue	# Strategy Switch
4	36	10.30_a (10.1)	0.44_a (1.3)	0.30_a (1.8)	0.08_a (0.4)	3.67_a (3.2)
6	41	1.10_b (2.1)	0.85_a (1.2)	1.80_b (4.1)	1.10_b (1.4)	7.56_b (3.6)
8	41	0.30_c (0.6)	0.51_a (0.9)	0.07_a (0.3)	0.68_b (1.6)	10.20_c (3.5)

Note. Means in the same column that do not share a subscript differ at $p < .001$ in the SIDAK pairwise comparison.

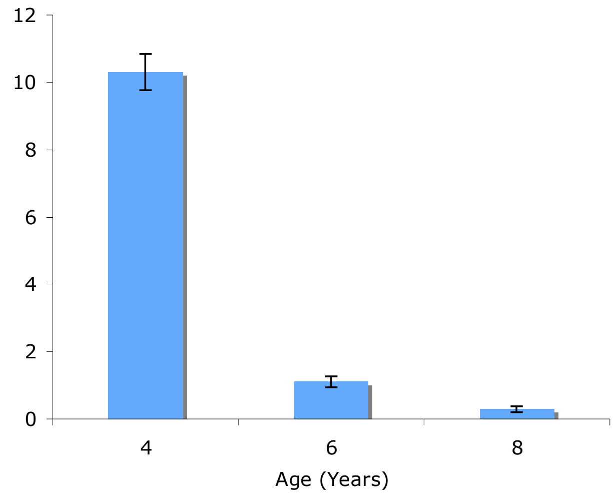

Figure 3. Mean number of explicit revelations by age, out of 20 trials. Vertical lines depict standard error of the means. All pairwise comparisons, $p < .001$

Though sex differences were not of primary interest in the current study, we found a significant effect of sex on explicit revelations, *Wald* $\chi^2(1, N = 118) = 41.7$, $p < .001$ (see Table H.2.), with boys revealing more than twice as much information than girls, on average (boys $x = 4.7$, girls $x = 2.4$). In other words, girls were more successful at not verbalizing or showing the hidden card to their opponent than were boys.

Accidental Revelations

Examination of accidental revelations revealed a different pattern of results (see Figure 4 for an example of an accidental revelation). Though there were still significant differences by age, *Wald* $\chi^2(2, N = 118) = 6.1$, $p = .048$, post hoc analysis revealed that 6-year-olds accidentally revealed more information than 4- or 8-year-olds (See Table 2 and Figure 5), but when this finding was subjected to the stringent requirements inherent in the SIDAK correction, this difference no longer reached significance levels.

Figure 4. Example of Accidental Revelation Behavior.

Camera is from the perspective of the examiner. Child carefully looks at card and even pointed to the incorrect color in an attempt to mislead the examiner, but his behavior (not keeping the card hidden from the examiner’s perspective) had already revealed pertinent information.

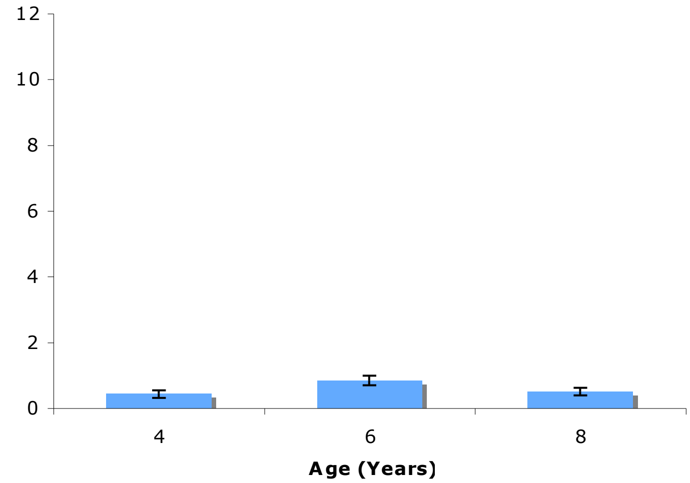

Figure 5. Mean number of accidental revelations by age, out of 20 trials. Vertical lines depict standard error of the means. Though there was an overall significant difference by age, there were no individual significant differences resulting from pairwise comparisons: 4-year-olds - 6-year-olds, p = .072; 4-year-olds - 8-year-olds, p = .963; 6-year-olds - 8-year-olds, p =.173.

There were no significant effects for sex for accidental revelations (see Table H.2.).

Hypothesis 3: Age Trends in Attempts to Hide Information

It was predicted that understanding and ability to hide information from a competitive partner would increase with age (see Figure 6 for an example of hiding behavior). Analysis revealed that there was a significant age effect for attempts at hiding information, *Wald* $\chi^2(2, N = 118) = 55.9$, $p < .001$. Post hoc analysis revealed that hiding behavior did not show a linear increase with age (see Table 2). Six-year-olds were found to make significantly more attempts to hide information on average than either 4- or 8-year-olds (see Figure 7). Six-year-olds used obvious strategies of hiding behaviors, such as hiding their face with the card, more often than either of the other two age groups, who did not significantly differ from one another.

Figure 6. Example of Hiding Behavior.

Child conceals face with card, hiding any information that the partner might gain from his facial cues.

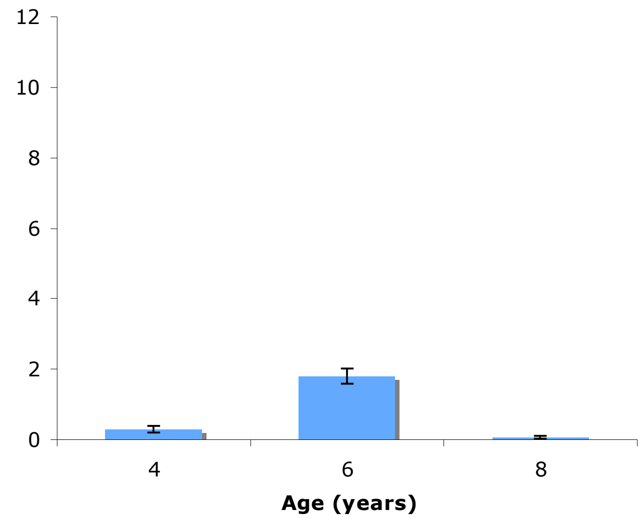

Figure 7. Mean number of hiding behaviors by age, out of 20 trials.

Vertical lines depict standard error of the means. Pairwise comparisons reveal: 4-year-olds - 6-year-olds, $p < .001$; 4-year-olds - 8-year-olds, $p = .064$; 6-year-olds - 8-year-olds, $p < .001$.

Though sex differences were not anticipated, there was a significant effect for sex in attempts to hide information, *Wald* $\chi^2(1, N = 118) = 10.2$, $p = .001$ (See Table H.2.), with boys making twice as many attempts at inhibiting information on average than girls (boys $x = 1.0$, girls $x = 0.5$).

Hypothesis 4: Age Trends in Fabrication Behaviors

False Cues

Analysis revealed that there were significant age differences in the number of false cues provided by age, *Wald* $\chi^2(2, N = 118) = 19.8$, $p < .001$. In line with our hypotheses, a post hoc analysis revealed that 6- and 8-year-olds were more likely to provide salient false cues to attempt to mislead a partner than

4-year-olds (see Table 2 and Figure 8). There were no significant effects for sex for false cues (see Table H.2.).

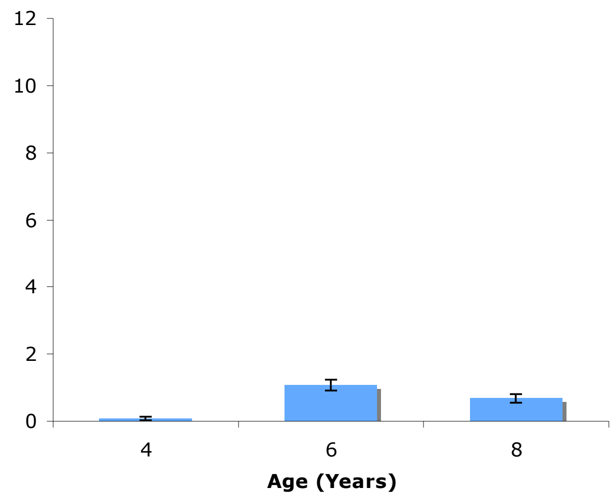

Figure 8. Mean number of false cues by age, out of 20 trials.

Vertical lines depict standard error of the means. Pairwise comparisons reveal: 4-year-olds - 6-year-olds, $p < .001$; 4-year-olds - 8-year-olds, $p < .001$; 6-year-olds - 8-year-olds, $p = .17$.

Number of Changes in Pointing Strategy

As predicted, there were significant differences in the number of times a child changed his/her pointing strategy by age, *Wald* $\chi^2(2, N = 118) = 105.5$, $p < .001$ (see Figure 9 for an example of change in pointing strategy). A post hoc analysis showed that 8-year-olds were significantly more likely to vary their pointing strategy more frequently than 6-year-olds who were significantly more likely to vary it more frequently than 4-year-olds (see Table 2 and Figure 10).

Figure 9. Example of a Strategy Switch.

Child won card after switching her strategy from pointing to the correct color to pointing to the incorrect color.

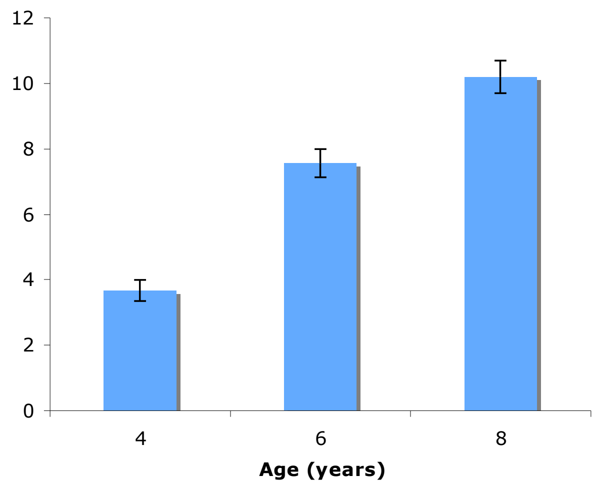

Figure 10. Mean number of times children changed their pointing strategy during the game, out of 20 trials.

Vertical lines depict standard error of the means. All pairwise comparisons reveal $p < .001$.

Hypothesis 5: Developmental Differences in Verbal Report

Based on interview categorization, we found a significant age effect for verbal confirmation of a developing RAI, $F(2, 115) = 29.9$, $p < .001$. Post hoc analysis showed that 8-year-olds were significantly more likely to have an awareness of recursive intentionality than 6-year-olds ($p < .001$), who were more likely than 4-year olds ($p = .001$). Cross tabs analysis revealed the directional and stage-like development of this trait with over half of the 4-year olds showing no indication of a RAI, well over a half of 6-year-olds showing at least some awareness, and nearly all of the 8-year-olds demonstrating full awareness of RAI as measured by this task (see Figure 11 and Table H.5.).

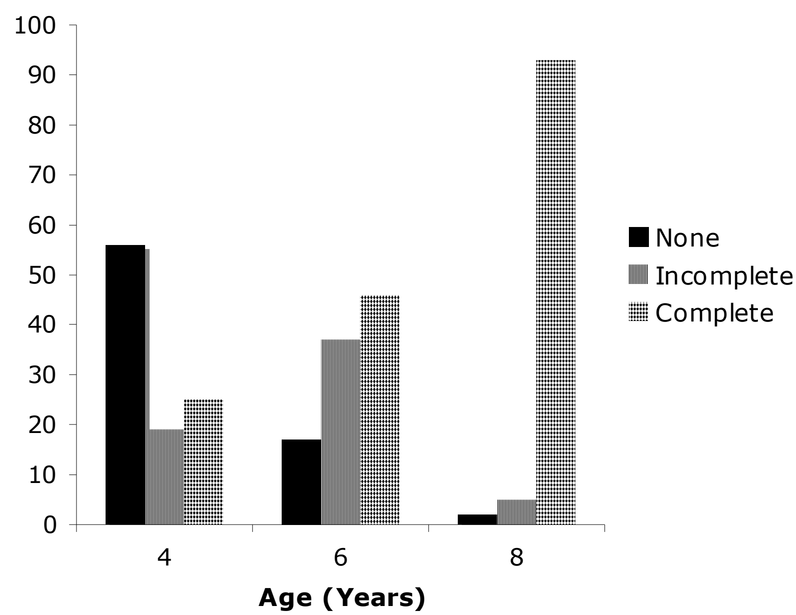

Figure 11. Percentage of children at each age in each of the three categories of level of recursive awareness understanding based on follow-up interview data.

Chapter IV

DISCUSSION EXPERIMENT 1

Results of the present study revealed that there is minimal recursive awareness of intentionality (RAI) at the age when children typically pass false-belief tests. Rather, RAI develops throughout middle childhood with significant differences emerging between 4, 6, and 8 years of age. As hypothesized, results demonstrated a clear age trend in the emergence of RAI ability as revealed in several ways, including: 1) a significant increase in the number of children who achieved the success criterion with age, 2) a significant increase in the number of times a child changed their pointing strategy with age, and 3) a significant increase in verification of understanding of RAI through verbal reports by the child with age. We first discuss each of these findings and then explore other behavioral data that may also lend insight into how this emerging ability develops.

Though several trends emerged in the data from the 4-, 6-, and 8-year-olds examined, the most revealing finding that supports a developing understanding of RAI is that children were increasingly likely to reach the success criterion with age. To be successful at the task, the child was required to conceal information from an opponent. The ability to conceal information required that the child not only be aware of what signals would be informative to a partner (RAI) but also have the ability to suppress or alter such signals effectively. The 8-year-olds were significantly better at achieving this goal than the 6-year-olds who were significantly better than the 4-year-olds.

As we look more closely at the behaviors that supported this increase in overall success, two primary behavioral factors emerged. First, the number of times a child changed his/her pointing strategy across trials (e.g., first pointing to the correct color then pointing to the incorrect color on a subsequent trial, then back again) was directly correlated with his/her success at the task. A substantial increase in the number of changes in pointing strategy emerged over the three age groups. This increased flexibility of changing the pointing strategy reveals awareness that the examiner was using repetitions in the child's pointing cue as informative for her guess. Frequently changing the pointing strategy makes it more difficult for an opponent to gain a strategic advantage in the game and reveals that the child is aware of this dynamic aspect. On average, the 4-year-olds switched their pointing strategy fewer than four times per 20 card set, the 6-year-olds switched almost eight times, and the 8-year-olds switched more than ten times (see Table 2).

The second factor that revealed evidence for increasing RAI with age was children's own insight about their strategy as indicated by children's verbalizations about the task. Following the task, children were asked non-leading questions concerning their strategic approach to the game. The results of this interview provided even more concrete evidence about the development of RAI across the age groups examined. Verbal responses to questions inquiring about the child's understanding and strategy use during the task were used to categorize children into one of three levels: no indication of RAI, incomplete RAI, and complete RAI. As hypothesized, with age, there was a steady decrease in the percentage of children who gave no indication of recursive awareness (56% at the 4-year-old level to 17% at the 6-year-old level to 2% at the 8-year-old level), a marked increase in the percentage who demonstrated a complete understanding of recursive awareness (25% to 46% to 93%), and a transient phase of incomplete awareness that peaked in the 6-year-old age group (19% to 37% to 5%) (See Figure 11; Table H.5). These trends demonstrate the emergence of a more complete understanding of RAI across these middle childhood years. Children were categorized based on their performance on the task as well as their verbal report to follow-up questions. While there were instances where a child appeared to be using an understanding of recursive awareness to mislead their opponent yet were unable to verbalize it (demonstrating an incomplete understanding), there were no instances where a child could verbalize it without having put it into action, for at least a portion of the game play. Children appeared to grasp the concept of manipulating their behavior even before they were able to provide a coherent explanation and this transitory partial understanding phase was more prominent in the 6-year-old group. Four-year-olds were more likely to give no indication of recursive awareness in behavior or verbal report and 8-year-olds were more likely to provide conclusive understanding of recursive ability regardless of the medium through which it was elicited. This progression of understanding RAI translated to the increase in success we saw over the three age groups with only 11% of the 4-year-olds reaching the success criterion on the task, 49% of the 6-year-olds reaching success criterion, and finally 76% of the 8-year-olds performing successfully at the task.

Other behaviors examined in this study did not show linear development with age, but examination of such behaviors reveal clues about how RAI may develop. The 4-year-olds in our sample explicitly revealed information (i.e., showed or verbalized the correct answer) much more than either of the other two age groups. They made fewer attempts to conceal information than the older groups and thus an adult partner had access to the information that the child had been instructed to hide. Due to this behavior, it is difficult to comment on 4-year-olds' level of recursive awareness because they did not demonstrate the competitive motivation that would necessitate strategic attempts. We can comment, however, that even though 4-year-olds are considered to have a mature theory of mind (TOM), other factors appear to be required before they can functionally apply such knowledge during a competitive exchange.

More informative were the children who demonstrated awareness of the need for a recursive strategy yet were unsuccessful in carrying it out. Behaviors that demonstrated emerging RAI were characteristic of the 6-year-old age group and were demonstrated by accidental revelation of information, salient attempts at inhibiting or hiding information, and attempts at providing misinformation. Unlike many of the 4-year-olds, the 6-year-old group tended to demonstrate an understanding of the competitive nature of the current design. They showed visible attempts at hiding information and superficially attempted to mislead their opponent. Yet, unlike the 8-year-olds, the 6-year-olds were still more likely to leak information by looking at, orienting to, or verbalizing the correct answer. Six-year-olds showed awareness that partners may be using their behavior to gain information, but they were still very poor at recognizing and concealing such pertinent behaviors. Where the 4-year-olds could be characterized by explicit revelation of information, the 6-year-olds showed an increase in accidental revelations, attempts at hiding information, and generation of false information. This shows development in understanding of the task as well as the knowledge that they have the potential to influence a partner with their behavior. However, even at 6 years of age, children still had difficulty in carrying out these intentions. Six-year-olds generally attempted to conceal information, but did so with varying levels of success. For example, one child turned his body all the way around in his seat in an attempt to ensure that the examiner would not see the card, but by doing so, he merely put it in the examiner's direct line of sight. Also, children would sometimes carefully conceal the card and then after looking at it, they would accidentally show it while giving their hint to the examiner.

As children (i.e., 6-year-olds in our sample) become more aware that they can increase their success by concealing information from their partner, we see the emergence of salient hiding behaviors. Our 6-year-olds showed a peak of hiding behaviors consisting of hiding their face with the card or hiding their body under the table. They demonstrated an understanding of some cues a partner may use to gain access to private information and they tended to attempt to suppress or inhibit such cues. These hiding behaviors proved to be a more successful strategy for keeping information from a social partner, but they created choppy and disjointed interactions. For example, children employing hiding strategies were observed to avoid eye contact, held their bodies stiffly, hid beneath the table, and avoided verbal communication. These tactics did make them more successful in the game paradigm than younger groups who did not demonstrate such attempts, but these behaviors would certainly stand out in other social situations. It was predicted that inhibition of revealing behaviors would increase over the age groups examined, but we found that such behaviors were rare in the 4-year-old group, peaked within the 6-year-old group and then dropped off again in the 8-year-old group. Therefore, it is likely that this is a transient strategy as children begin to develop RAI. Specifically, as children become aware that they are giving away information through their behavior, their first line of defense is to physically hide such cues. As they become increasingly able to control their behavior, they are free to adopt more subtle and effective strategies. Thus, in the 8-year-old age group, hiding behaviors were almost nonexistent, with children likely adopting more mature strategies and demonstrating more confidence and more success in their ability to conceal information through control and manipulation of their facial expression without needing to physically hide their face or body.

The 6- and 8-year-old groups also demonstrated the strategy of providing false cues to their opponent, a rare behavior that was virtually absent in the 4-year-old age group. Rather than merely inhibiting information in an obvious manner, the 6- and 8-year-olds began to demonstrate attempts of actively fabricating information. By substituting a false cue, older children could potentially keep the social interaction smooth even while actively misleading a partner. Such cues went beyond a hiding strategy and attempted to mislead an opponent through actively creating a false belief. This strategy could be considered more mature and more effective because rather than merely attempting to suppress all information with the risk of leaking information through the eyes or face, these children provided a wealth of false information, among which, true information would be more difficult to distinguish. The social interaction would be smoother, with children looking at the examiner and both cards.

It was originally hypothesized that 8-year-olds would provide significantly more false information than 6-year-olds, but examination of the behaviors revealed no significant difference between the two age groups and, in fact, 6-year-olds provided more false cues on average than 8-year-olds. One possible explanation for this unexpected finding may have to do with which behaviors were coded. Only salient hiding or fabrication attempts (e.g., covering the face with card or purposeful looking towards the wrong card) were possible to count. More subtle behaviors (e.g., keeping eyes trained on target card or looking at both cards equally) may be more mature strategies that were less noticeable and therefore also more difficult for behavioral coders to count. Thus the 8-year-olds, again, may have been using more mature strategies than would have been detectable in the current paradigm. Logically, one who is effective at providing false information should be able to do so without such cues (e.g., minutely glancing at incorrect color before pointing to correct color) looking out of place. The noticeable, countable behaviors were likely the more immature attempts. Such behaviors were most noticeable in the 6-year-old group, which is likely the group that was just learning to employ them. The emergence of such behaviors by 6 years of age did, however, demonstrate the emergence of recursive awareness. These children were aware that others are monitoring their nonverbal behavior and through their actions they revealed awareness that they have the ability to mislead others by manipulating their nonverbal signals. This is likely not dissimilar to the adult ability that makes us savvy social competitors. To interact effectively in a competitive situation, people may need to subtly hide their true intentions while broadcasting fabricated ones. Six and 8-year-olds not only demonstrated awareness of what cues may play a role in this broadcast, but also showed attempts at altering such cues. These attempts demonstrated that the children have at least a cursory understanding of how a social partner may interpret the situation as well as the signals given.

As shown in previous research (Feldman et al., 1979; Gosselin, Warren, & Diotte, 2002; Josephs, 1994; LaFreniere, 1988; Ruihe & Guoliang, 2006; Saarni, 1984), masking rather than neutralization of an emotional expression is generally a more effective strategy because the interaction remains smooth and the partner is less aware that something is amiss. Children who competed effectively in this paradigm shifted their strategy, provided a range of misleading cues (e.g., looked at correct card sometimes and incorrect card other times, verbalized correct/incorrect answer) and generally actively engaged their partner rather than withdrawing in an attempt to suppress information. This is likely a product of increased insight into a partner's thoughts and beliefs and one's increased insight into how a partner may be interpreting one's own thoughts, as well as increased confidence in one's own abilities to keep true information to oneself and only let out that information which one so chooses.

Though both 6- and 8-year-olds demonstrated attempts at social manipulation through attempts at hiding informative behaviors and providing false information, it still remains that 8-year-olds were significantly more successful overall at the task. As noted previously, the primary difference in the behaviors of the 6- and 8-year-olds was the flexibility with which they changed their pointing strategy. Where 4-year-olds were likely to perseverate in pointing to either the correct card or the incorrect card, 8-year-olds would vary their pointing frequently enough to decrease its informative value back to chance. Though 6-year-olds were beginning to use a more flexible strategy, responding when their opponent started using it to guess correctly, 8-year-olds were anticipating the response of the opponent and proactively shifting the veracity of their pointing clues. This is the most mature strategy to mislead an opponent because the point ceases to have any predictable meaning and thus the child has successfully reduced the opponent's probability of guessing correctly back to chance levels. Furthermore, interview responses demonstrated that by 8 years of age, children were better able to verbalize and conceptualize the mental processes necessary to understand RAI. These increased verbal/cognitive skills likely contribute to solidifying their understanding of RAI, even further increasing their chance of success at the game.

In the current paradigm, gender differences were not anticipated. Despite that expectation, some gender differences did emerge. Boys were more likely to explicitly reveal information than girls, with boys revealing twice as much information on average than girls. Boys were also more likely to show visible attempts at inhibition of information than girls, with boys making twice as many attempts at inhibition on average than girls. These gender differences are interesting to consider. They suggest that girls may demonstrate the awareness and the motivation to suppress overt telling behaviors developmentally earlier than boys. They also suggest that boys may use the immature 'hiding' strategy to a greater extent than girls. These two gender differences taken together provide suggestive evidence that RAI may develop earlier in girls than in boys. These differences have potential evolutionary and socialization support if differing gender roles are taken into account. For example, girls have been found to be oriented to the faces of others at an earlier age than boys (Baron-Cohen, 2005). Such selective attention, which orients females to increased social bonding in preparation for later gender roles, may also serve to promote increased perspective taking which would directly influence the child's ability to know to keep the card hidden from the sight of the other. It has also been shown that girls and boys are socialized differently in our society. With cultural pressure on girls to be nice and helpful as well as evolutionary pressure to read offspring signals accurately, girls may have added pressure to react in socially acceptable ways, and thus have more motivation to be aware of and to effectively manipulate their nonverbal behavior more convincingly than their male counterparts. Both sexes were equally likely to pass or fail the task, but their observed behavior followed slightly different patterns. Whether these differences are of a motivational nature or developmental nature remains to be explored.

While even most 4-year-olds are considered to have acquired false-belief understanding and thus have a mature TOM, it becomes clear that such precursor ability is merely a building block for later interaction abilities and is by no means the end point of adult-like ability. Once false-belief ability is mastered, children have the necessary precursor pieces to begin to understand what another person might be thinking, what another person might be led to think, and how one's own actions can influence the other. Once that is accomplished a likely next step is the ability to understand how another person may be attempting to manipulate one's own beliefs and how one can use such knowledge to one's own strategic advantage in a competitive social situation. Exploration of this question will be addressed in the second experiment of this study. The questions posed throughout this project place the child in an active role of decoding social information and encoding it effectively to actively compete in the social world. Without this ability, a child would be merely at the mercy of the actions of those around him/her and goal directed social interaction would be stymied.

Chapter V

INTRODUCTION TO EXPERIMENT 2

The Present Study

In the present study, we propose that there will be age differences in a child's ability to use contingent nonverbal signals to compete effectively in a guessing game paradigm. In Experiment 1 we were interested in how and when children used an understanding of recursive awareness of intentionality (RAI) to influence their social interactions. Experiment 2 addressed how children use an understanding of RAI to make predictions during social exchanges, or how they decode the behavior of others.

Inspired by Freire, Eskritt, and Lee's (2004) and Schultz and Cloghesy's (1981) testing paradigms, three age groups were given opportunities to use an awareness of contingency detection to compete more effectively in a competitive game situation. The game was modified to examine children's ability to pick up on contingencies in a situation in which an RAI (understanding that they can use a partner's behavior to gain insight into their partner's intentions) would make them more effective competitors. We are primarily interested in developmental differences; therefore, hypotheses were formulated with respect to age. No sex differences were predicted for this experiment.

Basic Design

The present study engaged 4-, 6-, and 8-year-olds in a guessing game paradigm designed to examine age differences in children's ability to detect contingencies that reveal their partner's intentions. The game was played with a deck of cards turned face down and the child's goal in all conditions was to guess the color of the next card in the deck. The examiner looked at the top card and the child was asked to guess the color based on a clue given by the examiner. The veracity of the examiner's clue was contingent upon her facial expression. Children who learned this contingency were able to accurately "guess" the color of the card. The stimuli were presented via video in order to ensure that all children received a standardized presentation of the contingent facial expressions (see DVD in pocket).

Children completed Experiment 2 in the same session as Experiment 1. Based on pilot data with our youngest age group, the two experiments were designed to be completed in approximately 25 minutes in order to maximize the child's attention to the game. The two experiments were sequenced to minimize confounding effects. Experiment 1 was always completed first and gauged children's spontaneous strategies before they were exposed to adults' strategies in Experiment 2.

Dependent Variables

Children in all conditions were rated on how many cards they won. They were also categorized based on follow up interview data that were organized to assess their level of awareness of the contingency.

Developmental Hypotheses

According to previous research (Bakti, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000; Baron-Cohen, 2005; Freire, Eskritt, & Lee, 2004; Klinnert, 1984; LaFreniere, 1998; Nelson, 1987; Schultz & Cloghesy, 1981) children are aware and attend to nonverbal signals (i.e., pointing and eye gaze), from a very early age. Building upon this research, as well as research on other cognitive skills, such as RAI, that are thought to develop after the age of four, the following hypotheses were formulated for the second phase of the study:

1. It was expected that 8-year-olds would detect and use contingent facial expressions to modify their predictions about a partner's intentions more reliably than 6-year-olds who would detect and use the contingencies more than 4-year-olds.

2. It was predicted that the contingency where smiling was paired with trickery would be more readily learned than the contingency of neutral expression paired with trickery. This prediction comes from pilot data where smiling while attempting to trick a partner was very salient to children who were becoming aware of the informative value of nonverbal cues to make predictions. Therefore, it was expected that 8-year-olds would use the contingent facial expression

regardless of which condition they are placed in, 6-year-olds would detect the contingency between facial expression and intentions only during conditions where smiling behavior was paired with trickery and 4-year-olds would have the most difficulty detecting the contingency in all conditions.

3. Because children are aware of eye-gaze from early infancy, it was predicted that children would be able to use the pointing cues (conditions 1 and 2) as well as the eye-gaze cues (conditions 3 and 4) similarly when making predictions.

4. Eight-year-olds' verbal reports during the follow up interview were predicted to demonstrate a greater awareness of the contingency than 6-year-olds who were predicted to demonstrate a greater awareness than 4-year-olds.

Chapter VI

METHODS EXPERIMENT 2

Experiment 2: Decoding

Participants

Participants were the same as in Experiment 1 and completed Experiment 2 in the same 25-minute session (see Table 3). Only one child (a 4-year-old) was eliminated due to failure to complete any of the conditions in Experiment 2. The child left the room before Experiment 2 began and refused to return. Experiment 2 was always run second.

Table 3. Age and Sex of Participants

Age	Males	Females	Total
4-year-olds	21	14	35
6-year-olds	22	19	41
8-year-olds	20	21	41
Total	63	54	117

Materials

A DVD was created for Experiment 2 in order to ensure that each child received standardized presentation of the nonverbal signals and facial expressions that were to be used in the game scenario. Four 5-minute videos were used, one for each of the four possible experimental conditions. The videos were shown to the child on a MacBook Pro laptop.

Procedures

Children participated in two of four possible conditions that asked them to engage in a contingency detection paradigm modified from that developed by Schultz and Cloghesy (1981). These conditions examined children's natural ability to use a partner's facial expression to detect signals of intentionality. Conditions varied by nonverbal hint (pointing or glancing) and contingent facial expression (smiling and neutral face) to determine whether some contingencies are detected and learned earlier than others.

For all conditions, the shuffled deck of cards was placed face down in the center of a table with a red card placed face up to the left of the deck and a black card face up to the right. The examiner looked at the top card from the deck and then provided a hint about the hidden card (either pointing or glancing to one of the exposed cards on the table, depending on which condition was being run) after which the child was asked to guess the color (see Appendix B for full instructions to children).

In this experiment, *the veracity of the hint given was contingent upon the facial expression* of the experimenter/actor providing it. For example, in Condition 1, false hints (pointing to the wrong color) were consistently paired with smiling behavior while honest signals (pointing to the right color) were paired with a neutral expression. Recognition of the contingency provided the child with information about the intentions of the examiner and veracity of the hint given. To examine whether the medium and salience of the nonverbal hint impacted the child's performance, in half the conditions, the experimenter pointed at the correct/incorrect card (Conditions 1 & 2) and in the other half the experimenter merely glanced at the card (Conditions 3 & 4). The truthfulness of the pointing/glancing cues was similarly contingent upon face behavior.

Children in each age group were randomly assigned to condition 1 or 2 (where the nonverbal hint was pointing) and then also completed either condition 3 or 4 (eye-gaze conditions). Ultimately approximately equal numbers of each age group completed the four conditions, with the combination of conditions counterbalanced within each age group, with one quarter of the children completing conditions 1 and 3, one quarter completing 1 and 4, one quarter completing 2 and 3, and one quarter completing 2 and 4 (see Table 4).

Table 4. Children in Each Condition by Age

Age	N	Point: Condition 1 (smile=false)	Point: Condition 2 (smile=true)	Glance: Condition 3 (smile=false)	Glance: Condition 4 (smile=true)
4-year-olds	35	18	17	18	17
6-year-olds	41	21	20	22	19
8-year-olds	41	21	20	20	21
Total	117	60	57	60	57

Note. Each child completed two conditions.

A summary of the four conditions is as follows:

Condition 1: the actor *pointed* to one of the exposed cards to give the child a hint about the color of the hidden card. In this condition, the actor smiled when attempting to fool the child and kept a neutral expression when being honest.

Condition 2: the actor similarly *pointed* to one of the cards. This time, she kept a neutral expression when attempting to fool the child and smiled when being honest.

Condition 3: the actor purposefully *glanced* twice at one of the exposed cards to give the child a hint about the color of the hidden card. (After looking at the hidden card, the actor looked directly at the camera and then looked at one of the exposed cards for about one second, looked back at the camera, and then looked at the exposed card again for another second before looking back to the camera and pausing to give the child an opportunity to guess.) As in condition 1, she smiled when attempting to fool the child and kept a neutral expression when being honest.

Condition 4: the actor again *glanced* twice at one of the cards. As in condition 2, she kept a neutral expression when attempting to fool the child and smiled when being honest.

The four conditions systematically linked the veracity of the nonverbal hint (pointing or eye gaze) with a facial expression (smiling or neutral expression). For each condition, 12 practice trials were designed to provide the child with the opportunity to learn the contingency. The first four cards alternated between true/false hints, the second four were all true, and the third four were all false. Then the next 16 trials were randomly shuffled (8 true and 8 false hints) and this same random order was presented to each child to assess the child's understanding of the contingency (see Appendix F for Assessment Form). Following completion of the task, children were individually interviewed in an open-ended fashion to investigate their strategy for playing the game (see Appendix G).

In order to establish standardized presentation of the facial expression and nonverbal cues, a video was created in which an actor, "Mary," played the role of the experimenter (see DVD in pocket). Therefore, once children understood the task and were able to guess correctly on two consecutive honest practice trials with the examiner, they were asked to watch and interact with a video monitor while the examiner recorded their guesses. See Figure 12 for screen shots of the smiling and pointing conditions and the neutral and glancing conditions.

Figure 12. Screen shots of Experiment 2 Stimuli

The video presentation was paused only when the child needed more time to make his/her guess. Otherwise, the interaction between the child and Mary was fluid and several children believed Mary was actually interacting with them. If children asked, they were told that Mary was a video recording, like a TV show, and could not see them. However, a minority remained unconvinced and argued that she knew when they had guessed. Therefore, the ecological validity of the study is considered to be high. Children believed they were participating in a social exchange even when such exchange had been standardized.

Interview Data

In addition to pass/fail information we also analyzed the children based on follow-up interview data. Based on verbal reports elicited by open-ended interview questions immediately following the task, children were categorized into one of three groups: those providing 1) no indication of the contingency, 2) incomplete indication of the contingency, or 3) evidence of conclusive understanding of the contingency. Children who attributed no functional significance to the examiner's facial expression were recorded as having no awareness of the contingency. These children were still likely to comment on the salient expressions but would not make functional attributions. When asked about her face, they would report that she was sometimes 'happy,' sometimes 'mad,' or 'sad,' or 'ugly.' Children who demonstrated awareness through mention of the facial expression or who spontaneously made inaccurate comments about the contingency of the facial expression were recorded as having an incomplete understanding of the contingency. For example, some children verbalized an incorrect contingency and thus were not able to use it to reach success criterion. Children who were able to explain the correct contingency were recorded as having a complete awareness of the contingency.

Chapter VII

RESULTS EXPERIMENT 2

Analysis Strategy

A number of analytic strategies were used to examine developmental trends for the dependent variables of primary interest. Due to the mixed design of between- and within-subject variables, a mixed model analysis was used to analyze the data (Gravetter & Wallnau, 2000). Preliminary analyses will be presented first, followed by analyses specific to each hypothesis set forth by this study. Analyses of differences by age are of primary interest. For ease of interpretation, figures have been predominantly used throughout the text. For additional tables, see Appendix H.

Simple contingency detection results

Prior to Experiment 1, children were engaged in a simple contingency detection task to ensure their ability to detect basic contingencies. All children were successful in this simple preliminary task and thus were included in Experiment 2. Before beginning the standardized computer version of the more difficult contingency detection task for Experiment 2, all children completed practice trials to ensure their understanding of the game. Practice was continued until children guessed correctly 2 consecutive times. Most children guessed correctly on the first two cards given. The greatest number of practice trials necessary for any child was 5 cards. When children did guess incorrectly, it typically appeared that they were already anticipating being tricked and were attempting to ‘strike first’ rather than actually misunderstanding of the instructions.

Sex Differences

Before addressing individual hypotheses that were predominantly formulated with respect to age, sex differences were analyzed and these preliminary analyses revealed no significant effect of sex for overall pass/fail on the tasks in Experiment 2, $F(1, 232) = 3.00$, $p = 0.08$ (see Table H.6). Analysis of individual conditions similarly revealed no significant sex differences (see Table H.7). Because preliminary analyses did not reveal significant sex differences or age by sex interaction effects, data for boys and girls were collapsed for the remaining analyses.

Success Criteria Justification

The criterion for passing the task was defined as children choosing correctly at least 12 times out of the possible 16 test trials. Fewer than 12 correct choices likely represented chance responding due to the binomial probability estimates of performance by chance alone (see Figure 13 for estimates of chance responding). It was assumed that a child reaching 12 correct has surpassed chance levels of merely guessing ($p = .02$) and thus concluded that they were using the nonverbal behavior of their partner to inform their choices (see Figure 14).

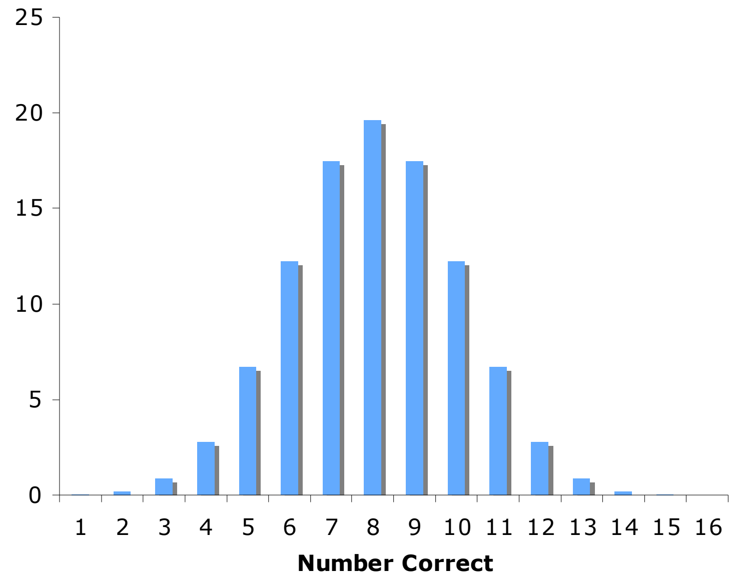

Figure 13. Normal Distribution. Expected percentage of number correct choices out of 16 trials based on chance responding.

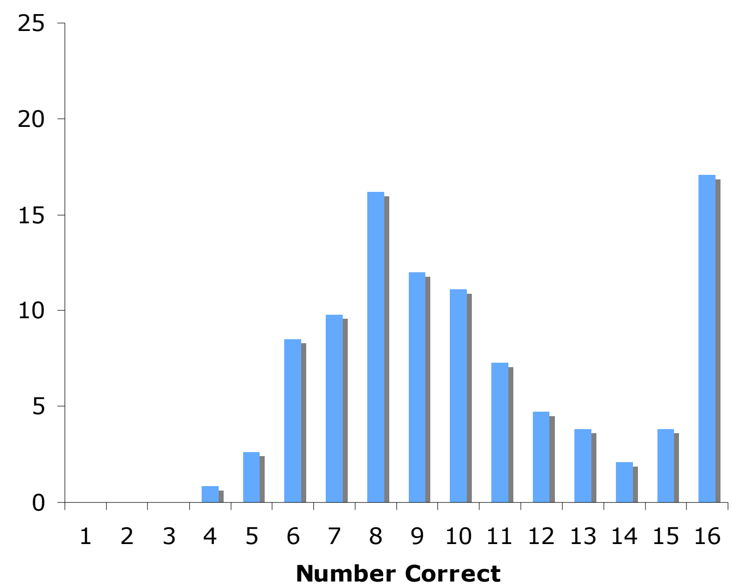

Figure 14. Histogram. Actual percentage of number of correct choices, out of 16 test trials, across all age groups for Experiment 2.

Based on probability estimates of performance by chance alone, to demonstrate an awareness of the nonverbal contingency children were required to guess correctly on at least 12 out of the 16 test trials. Figure 14 displays scores that approximately simulate those that would be expected based on probability estimates for chance performance (as shown in Figure 13). However, it also demonstrates a second peak reflecting those who were able to identify and utilize the nonverbal contingency to score beyond the level of chance on the task. This bimodal distribution likely reflects two populations, the first of which does not illustrate an awareness of the contingency and approximates the normal distribution based on chance responding and the second of which reflects an awareness of the nonverbal contingency and the ability to utilize such understanding to consistently respond correctly.

Hypothesis 1: Age Differences in Success Rate

In line with our first hypothesis, there was a significant main effect for age on reaching success criterion, $F(2, 112) = 8.8$, $p < .001$. Looking at the SIDAK post hoc pairwise comparisons for each of the age groups revealed that 8-year-olds were significantly more likely than 4- and 6-year-olds to draw information from the contingent facial expression when making their choice for all conditions, with 15% of the 4-year-olds reaching success criterion, 25% of the 6-year-olds and 53% of the 8-year-olds over all conditions (see Figure 15 and Table H.8).

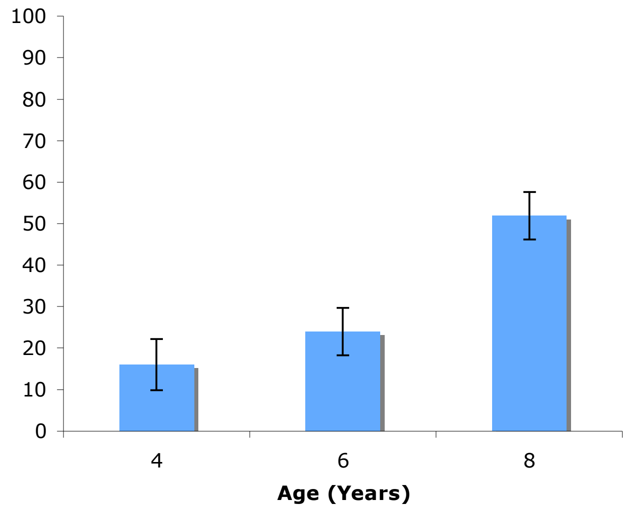

Figure 15. Percent of children reaching success criterion by age. Vertical lines depict standard error of the means.

Hypothesis 2: Contingent Facial Expression

Contrary to pilot data, the contingent facial expression (smile = true or smile = trick) did not have a significant effect on children's performance, $F(1, 112) = .11$, $p = .74$ (see Table H.9). Since there were no significant effects of contingent facial expression, the comparable conditions were collapsed for further analysis. Specifically, Conditions 1 and 2 varied only by contingent facial expression. Since there was no effect of facial expression, the two conditions were combined. Similarly, conditions 3 and 4 varied only by contingent facial expression and thus were collapsed into one data set.

Hypothesis 3: Social Cues

The social cue children received (pointing or glancing) had a significant effect on their performance, with pointing being easier overall, $F(2,109) = 12.6$, $p = .001$ (see Figure 16 and Table H.10).

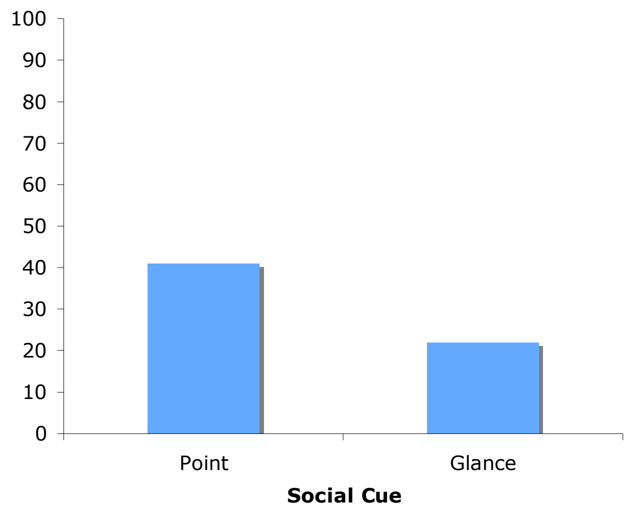

Figure 16. Percentage of children reaching success criterion for each social cue. Pointing was significantly easier than glance over all age groups, $F(2,109) = 12.6$, $p = .001$.

Furthermore, no interaction effects were found among any of our dependent variables (see Table H.11 for summary of significant and non-significant findings). Pairwise analyses by age revealed no further significant results.

Hypothesis 4: Developmental Differences in Verbal Report

Based on interview categorization, we found a significant stepwise increase with age for verbal confirmation of children's level of awareness of the contingency for each age group examined, $F(2, 112) = 27.7$, $p < .001$. Post hoc analysis revealed that 8-year-olds were significantly more likely to verbalize conclusive awareness of the contingency than either 4- and 6-year olds (4, 6 < 8, $p < .001$). Differences between 4- and 6-year olds were not significantly significant (4 = 6, $p = .13$) (see Figure 17 and Table H.12).

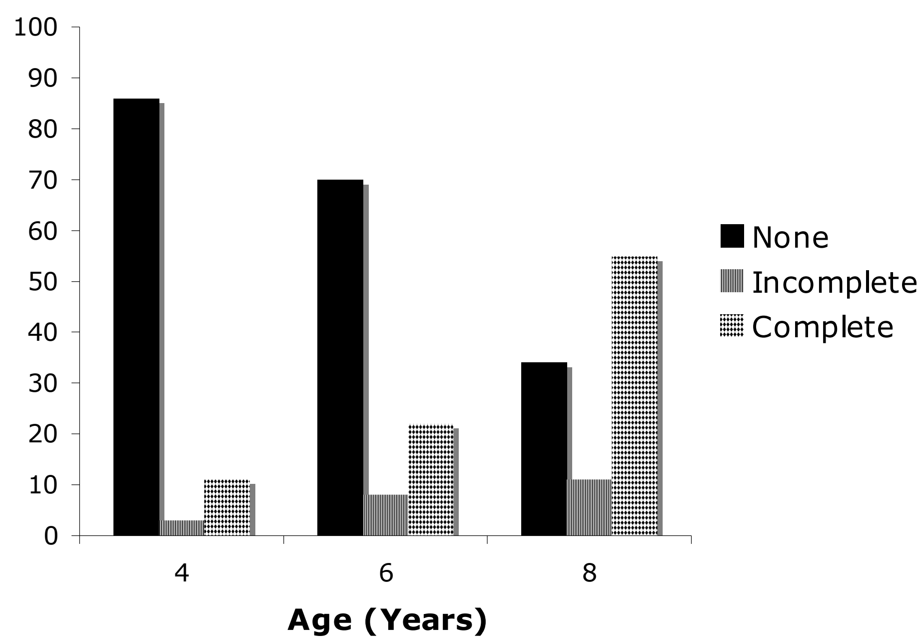

Figure 17. Percentage of children at each age in each of the three categories of level of understanding of contingency based on follow up interview data.

Chapter VIII

DISCUSSION EXPERIMENT 2

As hypothesized, results of the present study demonstrated significant age effects for children's ability to detect contingencies that provide insight into a partner's true intentions during an ongoing social interaction, as revealed by, 1) a significant increase in the number of children who achieved success criterion with age, and 2) a significant increase in verbal verification of the child's understanding of the contingency. There was also a significant effect for the social cue provided in the various conditions, demonstrating that children attribute more informative value to some cues than others. We will discuss each of these findings and explore other data that may influence our understanding of the development of social contingency detection in children.

An age trend emerged in the data supporting the hypothesis that the ability to use contingent nonverbal signals to make predictions about a partner's future behavior develops over middle childhood. The 8-year-olds in our sample performed significantly better than either the 4- or 6-year-old groups. The 8-year-olds were able to use the information provided by their partner's facial cues to alter their own behavior in an effective manner. They were significantly more aware of the contingency between their partner's facial expression and their future behavior and were able to interpret their partner's intentions in the game paradigm. Many factors likely contribute to this emerging ability, including experience with competitive situations, increased mastery of perspective taking and continued cognitive development. However, the difference in performance between the 8-year-olds and the younger groups demonstrates that children have not mastered all aspects of a mature theory of mind (TOM) at age 4, and that new abilities continue to emerge with development.

The second factor that revealed evidence for age trends for increasing functional meta-cognitive application of contingency detection abilities was the child's own insight about their awareness as indicated by their verbalizations in follow-up interview data. Following the task, children were asked non-leading questions about how they played the game. The results of this interview provided more evidence about the development of contingency detection across the age groups examined. Verbal responses to questions inquiring about the child's approach to the task were used to categorize the children into one of three levels: no indication of contingency, incomplete understanding of contingency, complete understanding of contingency.

As hypothesized, there was a significant age effect on children's understanding of the contingency in the task based on this interview data (See Figure 17 and Table H.12.).   With age there was a decrease in the percentage of children who showed no awareness of the contingency (86% at the 4-year-old level to 70% at the 6-year-old group to 34% at the 8-year-old group), an increase in the number who demonstrated incomplete awareness (3% to 8% to 11%), and an increase in the number who demonstrated complete awareness of the contingency (11% to 22% to 55%). These trends demonstrate that the ability to use nonverbal cues effectively in a competitive scenario emerges across these middle childhood years. As the data show, eight-year-olds were the most likely to demonstrate complete awareness of the contingency. They conclusively vocalized that the examiner's facial expression was a reliable cue to make conclusions about the veracity of her hint. These older children were more likely to see the cause/effect nature of the situation and to respond in a competitive fashion. Four- and six-year-olds demonstrated awareness of the varying facial cues (e.g., even 4-year-olds were likely to comment, "sometimes she was happy and sometimes she was mad" during the follow up interview) but were significantly less likely to recognize that such cues had informative value and consequently they were less successful at the game. Though 6-year-olds are not significantly different from our 4-year-olds, we can see that the trend is in the expected direction.

It is concluded that the ability to effectively recognize nonverbal behaviors as having informative value during an interaction requires false-belief mastery as well as advanced perspective taking skills, contingency detection ability in the social realm, an understanding of display rules, and the language development to express such a conceptual understanding of the mind and intentions of others. When framed in this manner, it is not surprising that our younger groups were unable to consistently be successful at the task.

Which cue the children received (pointing or glancing) had a significant effect on their performance, irrespective of age, with more children of all ages reaching success criterion in the pointing conditions. We know from past research that children selectively attend to eye-gaze as an informative cue from infancy. Therefore, it can be assumed the children in this experiment were aware of eye-gaze. However, there are several possibilities regarding how children perceived the eye gaze in the current study. Children may have attempted to use the eye-gaze cue to inform their choice. However, due to the competitive nature of the paradigm, it is difficult to predict whether children would choose the card that the actor looked at or if they would choose the opposite card. Either card would be a legitimate guess depending on the child's expectations and belief's about the actor's intentions. The only way to make conclusions about children's strategies would be through interview data, and, unfortunately, many children, even those who passed the task, frequently had difficulty giving us a full account of their game strategy. It is also possible that children may have not noticed the eye-gaze due to their attention on the cards or, more likely, may not have assigned informative value to it (Bering, 2006). Future replications of the paradigm may benefit from immediate query of the child after the first trial (i.e., why did you choose that one?) to see if they are referencing the eye gaze or merely making a random guess irrespective of the cues provided.

And finally, another possibility for the differential performance might be that the pointing cue was just more salient than the eye gaze cue, thereby allowing the children to more readily pick up on the contingency. Not only is a point a more sizable movement than an eye-shift, but task instructions also varied between the two cues (see Appendix B for all instructions given to child). In Conditions 1 and 2, children were specifically instructed that the actor was going to point to give them a hint. However, in Conditions 3 and 4, children were cautioned that the examiner was no longer going to point to the cards and it was only implicitly suggested that she would continue to give them some type of hint (i.e., “watch her carefully and see if you can guess the color.”). Regardless of the reason, the pointing cue was more useful for children to predict the color of the cards in the game. Likely this is a product of salience of the cue, whether it is through physical magnitude, instructional specificity, or experience with the cue itself.

Unlike pilot data, varying the facial expression that was paired with trickery did not affect the children’s performance. Pilot data had revealed that conditions where the smile was paired with tricking behavior were significantly easier for all age groups. It was hypothesized that in the child’s peer group, trickery is often accompanied with smiling and laughing behaviors. Based on this, it was hypothesized in the current study that a smile paired with tricking behavior would be more salient to the child and that children would demonstrate more successful contingency detection in such conditions. In the current study, however, children were able to detect the contingency between a smile and helping behavior and a smile and tricking behavior at about the same frequency. The current lack of such a significant difference is surprising. However, children’s vocalizations during a follow up interview were likely to include things like, “I know she is trying to trick me because she is laughing. When she’s not tricking me it isn’t funny” and “I know she is trying to help me because she looks nice. When she looks ugly I know she is trying to trick me.” Successful players seemed able to skew their interpretation of the emotional signal depending on its contingency in the current circumstance. Further research may illustrate whether the smile is an especially informative cue in the child's world or if other emotional expressions may serve similar purposes.

There is a strong body of literature examining the development of contingency detection throughout early childhood. From very early in infancy, infants have an awareness of contingency in the physical realm (e.g., Flavell, 1985; Millar & Weir, 1992; Rovee & Rovee, 1969;) as well as the social realm (e.g., Baron-Cohen, 2005; Leslie & Keeble, 1987; Rochat, 2001;). This experiment explored whether children in three age groups (4, 6, and 8 years of age) could use this understanding of contingency to gain insight into their partner's intentions in a competitive social interaction. We predicted that children's TOM is not mature by age 4, and thus, it was expected that we would see significant improvements in ability with age. Four-year-olds may be able to use facial cues and eye gaze to make basic, controlled predictions, but results of the current study demonstrate that children are unable to decode a partner's intentional state during an ongoing, contingent exchange, even after false-belief mastery. These results reinforce our position that TOM is not complete with the understanding of false-belief.

Chapter IX

GENERAL DISCUSSION

In both Experiment 1 and Experiment 2, 4-, 6-, and 8-year-olds demonstrated that there are aspects of theory of mind (TOM) that are not mature with false-belief mastery. In Experiment 1, 4-year-old children demonstrated a lack of awareness of how their own behavior may give a partner access to their intentions. In Experiment 2, children demonstrated difficulty inferring a partner's intentions even when provided with regular, contingent signals. Both of these abilities improved with age suggesting continued development of TOM beyond false-belief mastery. This final section will be concerned with comparison of these two experiments where possible. It will then discuss the implications of such results within a larger framework of TOM research. Finally it will acknowledge limitations and propose arenas for future study.

Due to methodological differences, statistical comparison of the results of Experiment 1 and Experiment 2 was not possible. However, there are several observations worth noting. Cursory examination of success rate and verbal reports suggests that Experiment 2 required more advanced recursive awareness of intention (RAI) abilities than Experiment 1, indicating that these two paradigms measured different levels of recursive ability. Overall success rate in Experiment 1 showed that three-fourths of 8-year-olds and half of 6-year-olds were reaching success criterion. In Experiment 2, however, only about half of the 8-year-olds reached success criterion and the 6-year-olds were not significantly different than the 4-year-olds. Furthermore, examination of verbal reports during the interview sections of the tasks showed a similar pattern. There were significant increases in RAI understanding with age for both experiments, but the rate of improvement with age varied between the two tasks.

When given an opportunity to talk about their strategies to conceal information from a partner (Experiment 1), one fourth of 4-year-olds could discuss necessary tactics, some even before they could carry them out to success criterion. By 6, half of the children demonstrated verbal understanding of RAI, and by 8, nearly all could verbalize strategies they used to mislead an adult partner. When given an opportunity to talk about how they could decode hidden information given by a social partner (Experiment 2), however, development was not as advanced. By age 4, only about 10% of the children could discuss how they could infer their partner's intentions. By age 6, one fourth demonstrated such an understanding, and by age 8, still only half could discuss such recursive strategies. These results appear to lend support to the Piagetian model that production generally precedes comprehension, as children demonstrated the ability to use deceptive tactics before they comprehended that others may employ them (Flavell, Miller, & Miller, 1993; LaFreniere, 2000).

Development of RAI can be delineated into several levels with increasing complexity. Children become: 1) aware of their own intentions, 2) aware of the intentions of the other, 3) aware of the other attempting to perceive their own intentions, 4) aware that the other may be aware that the child is attempting to perceive, and so forth. Logically these different levels must succeed each other in development since one cannot attribute mental states to others that one does not understand that one possesses. Children must be aware of themselves as an intentional agent before they can grasp that the other may have intentions as well (Flavell, Miller, & Miller, 1993; LaFreniere, 2000). They must then be aware that the other has intentions before they can be aware of the other intending to access the child's intentions. Each loop of recursive awareness demands greater cognitive ability and only the simplest of these, awareness that others have thoughts and beliefs that may be different than the child's own, is present with false-belief mastery at age four. Subsequent levels of understanding are not developed by age 4 and emerge throughout middle childhood, with simpler stages developing earlier than more complex ones.

Experiment 1 required children to form a plan of action, that is to say, to behave intentionally, and also to be aware that the other may try to discover just what those intentions are. To be successful children needed to alter their behavior to actively mislead the other. Experiment 2 required that children attempt to discover the intentions of the other, and also to be aware that the other may be changing her behavior to actively mislead the child. To be successful children needed to correctly read the contingent behavior of the other to not be misled. This ability logically requires an extra recursive step (the child taking into account the partner-taking-into-account the child's beliefs), which provides an explanation of why children were less likely to be as successful during the second experiment.

Children's specific behavior similarly demonstrated development, as behaviors characteristic of children who performed poorly at the tasks were different than the behaviors characteristic of children who completed the tasks successfully. In Experiment 1, the primary requirement was the awareness that one's own behaviors provided information to an opponent. To be successful, not only did the participants need to be aware of which behaviors provided information, but they also had to control them effectively. As demonstrated in the current results, children first attempted to suppress telling behaviors. For example, it was very characteristic of the younger groups to stare at the card in their hand and point blindly to the red or the black card, refusing to look in either direction, effectively suppressing any eye-gaze information. In contrast, older children demonstrated more confidence in their ability to suppress cues and even fabricated behaviors to more actively mislead. Thus, they would look at the wrong card in an attempt to get their opponent to choose that card. They were aware that the adult was using more than just the pointing strategy to make a guess and thus they cleverly 'leaked' information in a controlled manner. Furthermore, unlike in the younger groups where such false cues became predictable in themselves (e.g., once the examiner learned that the child was always pointing to the wrong card, she could use that information to make the correct choice), the oldest group demonstrated the ability to use a mixed strategy to more effectively mislead the opponent. They would sometimes look at the right card, sometimes look at the wrong card, and let the information 'slip' in other ways (e.g., one child said, "It's red. I promise," knowing that the examiner would think he was lying. Thus when the examiner inaccurately chose the black card, the child crowed, "I told you it was red!!!"). Such strategies only worked once if the child used them consistently, but the most successful children kept changing their strategy, thus leaving the examiner with no recourse other than a blind choice.

Behavioral data from Experiment 1 showed clear age trends in the ability to control and manipulate behavior to maximize effectiveness. First, they became aware of which behaviors to control, then they attempted to control them, and finally they fabricated false behaviors. Experiment 2 allowed for demonstration of similar development when children were required to infer information from the behaviors of others to compete effectively at the task. Again, the first requirement would be to recognize behaviors that may be informative and almost all children referenced and commented on the facial expression of the examiner, regardless of age. However, in the initial level of awareness, children commented on these contingent facial expressions but did not assign functional significance to them. Younger children would comment that "sometimes she is pretty and sometimes she is ugly" showing that they were aware of the varying expressions, but they were not using such expressions to guide their choices. In the older age groups, children began inferring information from such signals. They would comment, "I know she is helping me because she looks nice." Or, "I know she is tricking me because she thinks it's funny." These children clearly assigned meaning to the facial expression to help inform their choices. Unsurprisingly, children who were able to infer the intention behind the expression accurately were also able to consistently choose correctly. This ability varied with age, with older children identifying the functional value of such expressions most accurately, thus allowing them to make significantly more correct choices in the game paradigm. While even the youngest groups were identifying the facial expressions, only the oldest groups were inferring intention from them and using them to their competitive advantage.

RAI is a ubiquitous skill in the adult social experience. Understanding how one's own behavior may be viewed by another and managing it effectively is a critical component of social competence. Those aware of how they will be received will be more successful in eliciting cooperation or competing effectively. One must similarly have awareness of any potentially hidden intentions behind the actions of others. The inability to accurately interpret the behavior of others can lead to negative consequences like being taken advantage of in competitive contexts. Though these skills are taken for granted by the time one reaches adulthood, their development is not well understood. Many prerequisite abilities such as contingency detection (Flavell, 1985; Lemelin, Tarabulsky, & Provost, 2002; Lohaus et al., 2005; Millar & Weir, 1992; Rovee & Rovee, 1969), attention to eye gaze and facial expression (Bakti, et al., 2000; Baron-Cohen, 2005; Harris, 1993; Hood, Willen, & Driver, 1998; Klinnert, 1984; Meltzoff & Moore, 1989; Nelson, 1987; Pellicano & Rhodes, 2003) and false-belief mastery (Flavell, 1985; Flavell, 2000; Wellman, 1990; Wimmer & Perner, 1983; Woolley & Wellman, 1990) have been thoroughly studied. Now researchers must fill in some of the gaps between these early abilities and the more mature abilities demonstrated by adults.

The present study is one of the first that attempts to investigate developmental achievements that follow false-belief mastery. We caution that, while children have made many gains in understanding the minds of others by age 4, they still are lacking in some very fundamental areas. Specifically, they may be able to attribute emotion, thoughts, beliefs, or desires to others but they are not skilled at using these attributions to make accurate predictions for future behavior and they have similar deficiencies concerning the manipulation of such beliefs (Friere, Eskritt, & Lee, 2004; LaFreniere, 1988; Schultz & Cloghesy, 1981). These abilities are very likely to begin to develop shortly after the development of TOM as traditionally conceptualized, whether through experience, maturation, or a combination of these factors.

The results of the current study support the notion that RAI is not fully developed with the mastery of TOM as characterized by false-belief tasks and that it emerges over middle childhood. Based on this and similar research (Friere, Eskritt, & Lee, 2004; LaFreniere, 1988; Schultz & Cloghesy, 1981), sequential achievements can be conceptualized. Initially (4-year-olds) there is a lack of recursive ability characterized by children presenting as seemingly unaware of what behaviors they or a partner may use to gain access to information in the competitive situation. Interestingly, this stage overlaps that of traditional TOM achievement, revealing that recursive ability is not developed with TOM ability as characterized by false-belief mastery. The next age group (6-year-olds) demonstrated a growing awareness that was characterized by the child attempting to suppress telling behaviors. At this intermediate stage, children were aware of the most salient behaviors that a partner may use to gain information and attempted to inhibit them. While inhibition may not be an ideal strategy, it did allow children to be successful in the game paradigm in Experiment 1 significantly more often. However, they did not yet show a similar increase in ability in inferring the intentions of their game opponent in Experiment 2. Finally, in Experiment 1, older children (8-year-olds) demonstrated a more mature awareness of recursive interaction and began to substitute false cues to actively mislead a partner. Such a strategy was the most successful because honest signals were masked rather than suppressed. This oldest group was also able to infer the intentions of a partner based on nonverbal signals significantly more often than the younger groups.

This study adds to our understanding of the development of RAI and shows that there is certainly much left to consider. The interview portion of the study was invaluable to gain insight into how much the children actually understood about the recursive nature of intention. However, due to the limited verbal abilities of the younger preschool age group, they were likely at a disadvantage when being assessed via verbal report. There is a possibility that this age group may have had a greater understanding of RAI than they were able to express after completing the task.

The nature of the task also allowed children to interpret the examiner's/actor's intentions in various ways, which may have complicated the results. Children who were successful at the task frequently interpreted the facial expression in a way that was congruous with their appraisal of her intentions.

For example, in conditions where the smile was paired with inaccurate hints, successful children would verbalize that they knew she was trying to trick them because she had a tricky smile on her face. However, in conditions where the smile was paired with true hints, successful children frequently said that they knew she was telling the truth because she looked nice and helpful and when she did not look nice, they knew she was tricking them. Therefore, developmental differences in children's abilities to interpret non-social ambiguous situations could be further explored in an empirical manner that was not addressed in this study.

Further research could additionally delineate the developments that occur post false-belief mastery that contribute to an adult-level of social understanding. As demonstrated by the current results, even by age 8, success is not reached by 100% of the children. It may be interesting to apply the current methods to 10- or 12-year-olds, or beyond, to chart the course of further development of children's abilities to detect social contingencies and to influence the behavior of others. It would also be informative to gather additional interview data during the tasks (rather than immediately following) to gauge how children are thinking about the minds of others and how such interpretation influences their behavioral output. Also, similar research using a non-socially oriented paradigm may help delineate between general cognitive developments and TOM developments that are unique to the social setting. Finally, our current results show that children's understanding of the intricacies involved in RAI are not solidified even by age 8, with our different tasks revealing different levels of success at each age.

Therefore, alternate paradigms varying the methods used to target a child's ability to hide or infer intentions in a social setting may contribute to understanding some of the subtleties in this developmental process.

TOM is a complex ability that is generally considered to be unique to humans. We are a remarkably social species and our ability to produce and decode the very subtle social displays that are omnipresent in our social world *must* be developmentally supported. The current study suggests that TOM is not completely developed by age 4 as historically conceptualized in terms of false-belief mastery. Rather, the abilities that create an adult-like TOM continue to develop over middle childhood with children demonstrating increasing awareness of the mind and the intentions of the self and others with age.

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APPENDICES

Appendix A

Parent/Guardian Consent Form

PARENT/GUARDIAN CONSENT FORM

2007

Dear Parents/Guardians:

Your child has been invited to participate in a research project sponsored by the Department of Psychology at the University of Maine. Rachelle Smith, a doctoral student, and Dr. Peter LaFreniere, her faculty advisor, are conducting the project. We are interested in learning about how and at what age children use nonverbal cues (such as looking or pointing) to make predictions about the intentions of others. In addition, we are interested in exploring what nonverbal cues children use to influence a game-partner.

<u>What will your child be asked to do</u>? If you agree to allow your child to participate, her/she will be invited to play some card games with an adult examiner during their regular school day. The games involve guessing the color of the next card in a deck of cards. Children will get to have a turn trying to guess the next card and a turn looking at the card while the examiner guesses. The session will take about 25 minutes and will take place in a quiet location in the school. Children will be provided with simple instructions and then their play will be videotaped to determine what nonverbal cues they use to help them play. Regardless of performance on the card games, children will be rewarded with praise and stickers and will be given an opportunity to discuss how they played the game.

<u>Will answers be private and confidential</u>? All information obtained about each child will be private and kept confidential. The information will only be used for research purposes. Your child's name will never be associated with his/her responses. Your child will be given an ID number and only his/her age and gender will be recorded. The observation forms and videotapes will be stored in a locked laboratory room and will be kept indefinitely.

<u>Risks and Benefits</u>: The participation of your child in this study is voluntary. Your child may stop participating at any point. There is no penalty for a child who decides not to participate or stops in the middle of a session. Except for your child's time (approximately 25 minutes), there are no foreseeable risks to participating in this study. The benefits of this research are that we will learn more about when children begin to use nonverbal signals to predict and influence the behavior of others. In addition, your child will receive a small token of appreciation (e.g., stickers, pencil) as well as praise for a job well done.

<u>What do you need to do</u>? Please fill out and **return** the form on the next page to your child's classroom teacher **as soon as possible.**

<u>Contact Information</u>: If you have any questions about your child's rights as a research participant, please contact Gayle Anderson, Assistant to the University of Maine's Protection of Human Subjects Review Board, 581-1498 (or email her at gayle@maine.edu). If you have any questions or concerns about the research project, please feel free to contact Dr. Peter LaFreniere or Rachelle Smith at the address or phone number provided below.

Thank you for your help!

______________________________	______________________________
Rachelle Smith, B.A.	Peter LaFreniere, Ph.D.
Address: 301 Little Hall	Address: 301 Little Hall
Department of Psychology	Department of Psychology
University of Maine	University of Maine
Orono, ME 04469	Orono, ME 04469
E-mail:Rachelle.Smith@umit.maine.edu	Phone: 581-2044

Parent/Guardian consent form for the University of Maine research project on *Development of Theory of Mind after age four* conducted by Rachelle Smith and Peter LaFreniere.

PLEASE RETURN TO YOUR CHILD'S CLASSROOM TEACHER AS SOON AS POSSIBLE -- THANK YOU!

Please check whether or not your child has your permission to participate in this study:

_____ My child has permission to participate.

_____ My child does NOT have permission to participate in this study.

Child's name: ____

Gender: M or F (please circle one)

Birthday: ____/____/______

Grade: _______

Number of Siblings: _____________________________

Ages of Siblings: _______________________________

Teacher's Name: _______________________________

Parent's Name: ________________________________

Relationship to child (e.g., mother, father, guardian): ______________________

Parent/Guardian Signature: ______________________________________

Appendix B

Child Assent Form

CHILD (STUDENT) ASSENT FORM

Dear Student,

Hello! My name is Rachelle, and I am a college student at the University of Maine. Your parents have given you permission to play some different games that I have brought with me. You will get to play some of the games with cards and other games on the computer. I think that you will like the games!

After we play the games, I have some little prizes for you! The prizes are for working hard on the games and I think you can win one!

Do you have any questions?

Will you play the game with me?

1. Experiment 1

Introductory Task:

This is a guessing game. The game is played with a deck of cards. Each card is red or black (*show the cards as you name the color*). The game is to guess the color of the next card in these stacks (*point to the two stacks*). What color do you think this card is? What about his one? (*Alternate between decks until the child is able to successfully "guess" the color 6 consecutive times*). You did great! Let's try the next game!

A. Play the game.

Next you get to have a turn looking at the cards and I will try to guess what the color is! This time we just have one deck. You will look at the card and then point to either the red card or the black card to give me a hint. If I guess right, then I win the card. If you trick me and I guess wrong, then you win the card. Remember, try to win as many cards as you can! Okay?

(Video record interactions. Also record number of cards each participant won).

B. Interview
How did you play the game?
How did you win so many cards?
Did you try to trick me/him/her?
How?

(Record all responses on Interview Template 1, see Appendix C.).

2. Experiment 2

Conditions 1 & 2:

Now it is my turn to look at the cards. Just like before, the cards are either red or black (*point to the cards as you name the color*). I will look at the top card (*demonstrate*) and then point (*demonstrate*) to a card to give you a hint about what color it might be. But be careful! Sometimes I might try to fool you! If you get it right, you win a chip! At the end, you can trade your chips for some stickers. Do you understand?

Now you are going to watch a video and play the game with my friend Mary. Remember to watch carefully because sometimes Mary is tricky!

Conditions 3 & 4:

Now it is my turn to look at the cards. Just like before, the cards are either red or black (*point to the cards as you name the color*). I will look at the top card (*demonstrate*) and then you try to guess what color it might be. Remember, watch carefully and see if you can guess what color it is! If you get it right, you win a chip! At the end, you can trade your chips for some stickers. Do you understand?

Now you are going to watch a video and play the game with my friend Mary. Remember to watch carefully because sometimes Mary is tricky!

(Record all responses on Child Assessment Form, see Appendix F.).

B. Interview
How did you play the game?
How did you win so many cards?
She was tricky! How did you know when she was tricking you?
Did you see anything on her face?

(Record all responses on Interview Template 2, see Appendix G.).

Thank you for playing all of my games! You worked really hard! You can choose 5 stickers as a reward for your good work! Thanks again for playing!

Appendix C.

Interview Template 1

Interview Template 1:

Child's Name: ________________________________ Date: _______________

Childs Age: __________________________________ Gender: _____________

cards won:_________

How did you play the game?

How did you win so many cards?

Did you try to trick me/him/her?

How?

Mark one:

___ Provides no indication of awareness of intentionality.

___ Provides indication that had awareness of intentionality, but cannot explain.

___ Conclusively indicates an awareness of intentionality.

Appendix D

Coding of Behavior Template

Coding of Behavior Template:

Child's Name: _________________________________ Date: _______________
Childs Age: ___________________________________ Gender: _____________

Please count and detail each example of the following behaviors:

1. Explicit behaviors (e.g., showing card or verbalizing color) **Total** #_____

2. Leaked information (e.g., eye-gaze, body orientation indicating correct answer).

Total #_____

3. Suppression behaviors (e.g., purposefully not looking towards cards, avoiding eye-contact) **Total** #_____

4. Production of false cues (e.g., suggestive eye gaze to incorrect card, verbalization of wrong answer) **Total** #_____

Appendix E

Behavior Coding Instructions

Behavior Coding Instructions

Following are the categories from the behavior observation sheet. We can only observe behaviors, not intentions, so keep it objective – i.e., do not read into the behaviors, just look and record what you actually see.

1. Explicit Behaviors: Explicit behaviors include any behaviors that demonstrate that the child is unaware of what behaviors need to be inhibited in order to be successful at the guessing game.

A. Verbal Behaviors: The child tells the examiner the correct color of the card.

B. Physical Behaviors: The child purposefully shows the card to the examiner.

2. Leaked (Accidental) Behaviors: Leaked behaviors include any behaviors that give the examiner a clue as to the color of the hidden card. The child may demonstrate an understanding that such behaviors should be inhibited but the behaviors are not fully controlled and leak out anyway.

A. Eye gaze: The child's eye dart to the correct color after looking at the hidden card. Instances where the child looks at a card in preparation to point should not be included in this category. This glance should be quick, unconscious and not suppressed by the child.

B. Showing Card: The child understands that the card should be kept hidden from the examiner but is not sufficient in keeping it fully hidden. The child is not explicitly showing the card to the examiner, but reveals it accidentally. From the camera angle, it may be difficult to tell if I can see the card or not, but if I guess WRONG, then you know I didn't see it. I will be mindful when setting up the camera angle.

3. Suppression Behaviors: The child demonstrates an awareness of what cues the examiner is using to make a guess and makes a visible attempt to suppress such behaviors. Suppressed behaviors are behaviors that the child is attempting to control in order to more successfully mislead the examiner.

A. Occlusion**:** The child holds the card in front of his/her own face in order to occlude the view of the examiner. The child noticeably looks only to the hidden card and never to either of the stimulus cards in order to not give any additional information.

B. Other: Any other behaviors that demonstrate awareness of attempting to not give off any additional clues. If you come across any, please let me know so that we can conceptualize them and add them to this form. As we begin working with different age groups, different behaviors may emerge.

4. **Tactical Strategy**: The child demonstrates a strategy as they give hints. For each card, mark whether or not the child pointed to the correct (C) color or to the incorrect (I) color as well as whether or not the child was successful in winning the card (check mark for each card the child won). Then count the number of times the child switched strategy during the game (e.g., if they pointed to the correct (or incorrect) card on the first trial and then to the correct (or incorrect) card on every trial after that, they switched their strategy 0 times.) Also count and record the number of cards the child won.

5. **Production of False Cues**: The child demonstrates the awareness and ability to go beyond merely inhibiting their telling behaviors and attempts to produce misleading cues. As we begin working with different age groups, such behaviors may become more apparent.

A. Verbal Behaviors: e.g., the child says the card is one color and then immediately retracts it as if they accidentally let it slip to make you think that they revealed the color, but in actuality it is the other color. These should be relatively apparent, with the child acknowledging that they were trying to trick you the whole time.

B. Eye Gaze: The child blatantly looks to the incorrect color in an attempt to make examiner think they are leaking the information. We can only count these if they are blatant and we can agree on what we are seeing, so if it happens, I will try to get the child to verbalize it after the fact to see if they were aware of what they were doing.

C. Other: As we work with more savvy kids, we will see if any other productive clues emerge. If you start to see any, please bring them up with the group so we can add them to the form.

Appendix F

Child Assessment Form

Child Assessment Form

Child's Name: ______________________________ Date: ______________

Childs Age: ________________________________ Gender: ____________

Correct answer	Child's Response **Condition #___**	Child's Response **Condition #___**
Practice Trials		
1. Black (T)		
2. Black (F)		
3. Red (T)		
4. Red (F)		
5. Black (T)		
6. Red (T)		
7. Black (T)		
8. Red (T)		
9. Red (F)		
10. Black (F)		
11. Black (F)		
12. Black (F)		
Test Trials		
1. Red (T)		
2. Red (F)		
3. Black (F)		
4. Red (T)		
5. Red (F)		
6. Black (T)		
7. Red (T)		
8. Black (T)		
9. Red (F)		
10. Black (F)		
11. Black (T)		
12. Black (F)		
13. Red (T)		
14. Black (T)		
15. Red (F)		
16. Red (F)		
	# Correct: _____ /16 test trials	# Correct: _____ /16 test trials

Additional Comments/Observations:

Appendix G

Interview Template 2

Interview Template 2:

Child's Name: ______________________________ Date: ______________

Childs Age: ________________________________ Gender: ____________

\# Cards won: ________

How did you play the game?

How did you win so many cards?

She was tricky! How did you know when she was tricking you?

Did you see anything on her face?

Mark one:

___ Provides no indication of detecting a contingency

___ Provides indication that perceives a contingency but cannot elaborate or explain

___ Conclusively perceives contingency

Appendix H

Supplementary Tables

Table H 1. Experiment 1: Success Rate by Sex

Sex	N	% Pass (SD)
Male	64	47_a (50)
Female	54	46_a (50)

Note: Scores in the same column that do not share a subscript differ at $p < .05$.

Table H 2. Experiment 1: Mean (SD) of Behaviors of Interest by Sex

Age	N	Explicit Revelations	Accidental Revelations	Hiding Info.	False Cues	# Changes Pointing Strategy
Males	64	4.69_a(8.45)	$.61_a$(1.24)	$.98_a$(3.06)	$.67_a$(1.50)	7.27_a(4.34)
Females	54	2.37_b(5.17)	$.61_a$(1.04)	$.46_b$(2.28)	$.59_a$(1.16)	7.31_a(4.35)

Note. Means in the same column that do not share a subscript differ at $p = .001$.

Table H 3. Experiment 1: Success Rate by Age

Age	N	% Pass (SD)
4-year-olds	36	11_a (32)
6-year-olds	41	49_b (51)
8-year-olds	41	76_c (44)

Note. Means that do not share a subscript differ at $p <.02$ in the SIDAK pairwise comparison.

Table H 4. Experiment 1: Percentage of Children Who Demonstrated Behavior of Interest by Age.

Age	N	Explicit	Accidental	Hiding Information	False Cues	# Changes Pointing Strategy
4-year-olds	36	78 (44)	17 (0)	3 (3)	6 (0)	56 (11)
6-year-olds	41	41 (2)	44 (0)	32 (10)	44 (0)	88 (51)
8-year-olds	41	24 (0)	32 (0)	7 (0)	27 (0)	98 (68)

Note. Percentage Demonstrating Strategy (Percentage using as predominant strategy, i.e., more than half the trials).

Table H 5. Experiment 1: Level of Recursive Awareness of Intentionality During Follow-up Interview by Age.

	Percentage Level of Recursive Awareness of Intentionality		
Age	None	Incomplete	Complete
4-year-olds	56	19	25
6-year-olds	17	37	46
8-year-olds	2	5	93

Table H 6. Experiment 2: Overall Success Rate by Sex

Sex	N	% Pass (SD)
Male	130	27_a (45)
Female	104	38_a (49)

Note. Scores in the same column that do not share a subscript differ a $p < .05$.

Table H 7. Experiment 2: Success Rate for Each Condition by Sex

Condition	Sex	N	% Pass (SD)
1	Males	36	39 (49)
	Females	24	50 (51)
2	Males	29	34 (48)
	Females	28	43 (50)
3	Males	33	18 (39)
	Females	27	26 (45)
4	Males	32	16 (37)
	Females	25	32 (48)

Note. Sex did not have a significant effect on performance in any condition.

Table H 8. Experiment 2: Success Rate Across all Conditions by Age

Age	N	% Pass (SD)
4-year-olds	35	15_a (37)
6-year-olds	41	25_a (43)
8-year-olds	41	53_b (50)

Note. Means in the same column that do not share a subscript differ at $p < .01$ in the SIDAK pairwise comparison.

Table H 9. Experiment 2: Success Rate by Social Signal

Signal	Pass	Fail
Smile = fooling	33	67
Smile = honest signal	31	69

Note. Social signal did not have a significant effect on children's performance ($F(1, 112) = .113$, $p = .738$).

Table H 10. Experiment 2: Success Rate by Cue

Cue	Pass	Fail
Point (Cond. 1 + 2)	41	59
Glance (Cond 3 + 4)	22	78

Note. Cue received had a significant effect on children's performance (F(2, 109) = 12.590, p = .001).

Table H 11. Experiment 2: Summary of Findings

Independent Variable	df	F	Significance
Age	2, 112	8.780*	.001
Cue (point/glance)	1, 109	12.59*	.001
Signal (smile = true/false)	1, 182	.113	.738
Signal*Age	2, 182	.364	.695
Signal*Cue	1, 188	.615	.434
Age*Cue	2, 109	2.22	.113
Signal*Age*Cue	2, 188	.338	.714

Note. *p<.05

Table H 12. Experiment 2: Level of Awareness Across Conditions per Verbal Report by Age

	Percentage Level of Awareness		
Age	None	Incomplete	Complete
4-year-olds	86	3	11
6-year-olds	70	8	22
8-year-olds	34	11	55

BIOGRAPHY OF THE AUTHOR

Rachelle Smith was born in Tucson, Arizona on January 27, 1977. She attended high school in Presque Isle, Maine and graduated from Presque Isle High School in 1995. She then attended the University of Maine and graduated summa cum laude and with highest honors in 1999 with a Bachelor of Arts' degree in Psychology. After receiving her undergraduate degree, Rachelle worked as a Neurocognitive Testing Assistant at a brain injury clinic until 2003 and then at a private Neuropsychology practice. She entered the Developmental Psychology graduate program at the University of Maine in the fall of 2005. Upon entering the University of Maine, Rachelle was awarded the Provost Fellowship and then later received the Owen Aldis Award to fund her dissertation research. As a recipient of the Aldis Award, Rachelle had the opportunity to present at an international conference in Bologna, Italy in 2008. Rachelle is a member of the International Society for Human Ethology (ISHE), the Society for Research in Child Development (SRCD), and the North Eastern Evolutionary Psychology Society (NEEPS). She is a candidate for the Doctor of Philosophy degree in Developmental Psychology from The University of Maine in May 2009.