Novel Affective Theory of Mind Measures Assessing Simple versus Complex Emotions

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Abstract

Theory of mind (ToM) refers to the capacity to recognize that individuals have mental states such as beliefs, perspectives, and emotions that guide their behaviour. The measures that are currently used to assess ToM are highly dependent upon linguistic skill, and typically ignore affective ToM. In the present study, two non-verbal affective ToM tasks were created. The Affective Visual Theory of Mind Task (AVToM) assessed the perception of emotions such as happy or sad, while the Emotional Narrative Task (ENT) assessed the ability to recognize the more complicated emotion of embarrassment. Participants also completed two established ToM assessments, thus allowing us to examine the relationships between the various ToM tasks. Positive correlations were found between some of the different ToM measures; importantly, these relationships were not mediated by verbal skill. However, the correlations between the measures were weak, suggesting that each task may be assessing different, but overlapping, components of ToM.

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CHAPTER 1: INTRODUCTION

Theory of Mind (ToM) refers to the capacity to recognize and make judgements about the mental states of other individuals, including their beliefs, desires, intentions, knowledge, and emotions (Baron-Cohen *et al*., 1994). The term 'theory of mind' was first used by Premack and Woodruff (1978) in their seminal study examining whether chimpanzees could recognize intentional human actions. In their paradigm, chimpanzees were shown video clips of humans in challenging positions, such as not being able to reach a desired object. The chimps were then shown a number of pictures, one of which depicted the solution to the actor's dilemma, such as using a tool to extend their reach. The researchers found that chimpanzees consistently chose the picture that represented the best solution to the actor's predicament and therefore were able to correctly infer the actor's intentions. This original article on ToM led researchers to investigate this ability in human populations.

Over the past 30 years, research investigating ToM abilities in humans has proliferated, with the majority of studies focusing on how an individual acquires ToM and when such abilities are fully developed. As adults, we frequently explain other people's actions based on the joint interactions between desire and belief, what Wellman and Wooley (1990) describe as belief–desire psychology. For example, consider the scenario of Billy going to the grocery store. Healthy adults could interpret this behaviour as follows: Billy *wants* to buy groceries and *believes* that groceries can be purchased from that particular type of store. In this example, Billy's desires and beliefs are inferred in order to explain his behaviour. This reasoning is part of what constitutes a sophisticated ToM. ToM is fully developed when an individual is also able to recognize that another's belief can be disparate from one's own belief and/or from reality, and that individuals will act according to their own misconceptions. For example, John is looking for his cell phone in the basement because he believes that is where he left it, but in actuality the phone is in the kitchen. In summary, mature ToM abilities requires that an individual can 1) infer the mental states of others, 2) recognize that another individuals belief may be disparate from ones' own belief and/or reality and 3) be able to predict and explain an individual's actions based on their mental state. This ability has also been referred to as 'mind reading' (Baron-Cohen, 1995) or 'mentalizing' (Firth, Morton, & Leslie, 1991).

ToM is considered an advanced ability that is important for normal social interaction (Baron-Cohen, 1995). Without the ability to take another person's mental state into account it would be difficult to effectively interact with others or to create meaningful relationships. Imagine a scenario in which an individual says something hurtful to another person. If the individual does not have the ability to recognize the other person's hurt feelings, he or she will continue to say inappropriate things without realizing the negative impact of such actions. An individual devoid of ToM understanding will be unable to learn the nuances of appropriate social interaction or may avoid social interactions altogether (Baron-Cohen, 1995). On the other hand, individuals with superior ToM abilities demonstrate advanced social competencies. For example, children who score higher on ToM tasks have been shown to have more friends (Liddle & Nettle, 2006), deal more effectively with social disputes (Bosacki & Astington, 1999), and interact cooperatively with others (Paal & Bereczkei, 2007).

Evolutionary psychologists have posited that ToM understanding evolved in order for primates, especially humans, to live coherently in social groups (Baron-Cohen, 1995; see Brune & Brune-Chors, 2006, for a review). There are a number of advantages to living collectively, such as greater protection from threats in the environment and the sharing of responsibilities (Wilson, 1975). However, in order for group living to be successful, members have to be able to live harmoniously with one another and be able to detect when others are cheating or deceiving the group (Trivers, 1971). Thus, living in complex social environments may have required ToM abilities, in which an individual can infer the true intentions of others. This capacity may be one of many factors why the primate brain is much larger and convoluted when compared to the brains of other species (Brune & Brune-Chors, 2006). The idea that the human brain evolved to accommodate social reasoning suggests that this ability may be 'hard-wired' within humans. In support of this premise, several theorists have proposed that ToM development is based on the maturation of an innate mentalizing module (Leslie 1994), and other research has found that ToM is a cross-cultural universal phenomenon (Avis & Harris, 1991; Callaghan, Rochat, Lillard, Claux, Odden, Itakura, & Singh, 2005; Liu, Wellman, Tardif, & Sabbagh, 2008; Oberle, 2009; Shahaeian, Peterson, Slaughter, & Wellman, 2011; Wellman, Fang, Lui, & Lui, 2006). One question that arises is which areas of the brain support the ability to reason about mental states? One particular region that may have evolved in order for humans to be able to mentalize is the frontal cortex.

Support for the role of the frontal lobes in ToM can be found in a number of different lines of research. Neuroimaging experiments have reported frontal lobe activation in response to different types of ToM tasks (Baron-Cohen, Ring, Moriarty, Schmitz, Costa, & Ell, 1994; see Gallagher & Frith, 2003, for a review); this activity appears most pronounced in the medial regions (Fletcher, Happe, Frith, Baker, Dolan, Frackowiak, & Frith, 1995; Goel, Grafman, Sadato, & Hallett, 1995; Gallagher, Happe, Fletcher, & Frith, 2000; Gallagher, Jack, Roepstorff, & Frith, 2002). These findings are buttressed by the fact that individuals who have acquired frontal lobe damage show disturbances in ToM understanding (Rowe, Bullock, Polkey, & Morris, 2001; Stuss, Gallup, & Alexander, 2001). Baron-Cohen and colleagues (1994) have suggested that the frontal lobes are part of a neural circuit underlying ToM reasoning. This assertion is supported by the idea that the development of the frontal lobes directly coincides with the development of ToM abilities (Stone, Baron-Cohen, & Knight, 1998). The frontal lobes are a late-maturing area of the brain that continue to develop well into the teenage years. Similarly, the development of ToM understanding first begins in infancy with the ability to recognize intentional actions (Woodward, 1988). However, advanced ToM reasoning is not established until a child is between the ages of 9 and 11, when an adolescent can differentiate between two different mental states and can make appropriate emotional attributions (Baron-Cohen, O'Riardan, Stone, Jones, & Plaisted, 1999). This relationship suggests that there is a crucial relationship between ToM understanding and the maturation of the prefrontal cortex of the brain.

The neural network underlying social understanding is not limited to the frontal lobes, but also includes the limbic system (Baron-Cohen, Ring, Wheelright, Bullmore, Brammer, Simmons, & Williams, 1999). Neuroimaging studies have reported activation in the prefrontal cortex, the temporal lobe and the amygdala in response to ToM tasks (Baron-Cohen *et al*., 1999). Bishop (1993) commented on the importance of the connection between these three brain areas in ToM functioning by proposing that only areas of the prefrontal cortex that have reciprocal connections to the limbic system are important for ToM. One limbic structure that has received attention in regards to ToM functioning is the amygdala, which has been shown to have connections to the medial prefrontal cortex (Zald, 2003). Baron-Cohen and colleagues (1999, 2000) have suggested that the development of ToM understanding may be dependent upon healthy amygdala activity. This notion is supported by the finding that individuals who acquired amygdala damage early in life perform poorly on ToM tasks (Fine, Lumsden, & Blair, 2001).

Further evidence supporting the supposition that the amygdala plays an important role in ToM comes from studies on individuals with autism, a neurodevelopmental disorder characterized by inappropriate social behaviour and a lack of intimate relationships. Autistic individuals not only consistently fail ToM tasks (for a review, see Baron-Cohen, 2010), but also have been shown to have structural abnormalities of the amygdala (Abell, 1999). Baron-Cohen (2000) conducted a functional magnetic resonance imaging (fMRI) study examining the differences in brain activation in response to a ToM task with both autistic and healthy individuals. The researchers found that when compared to healthy controls, autistic participants showed no activation of the amygdala and very little activity in the frontal lobes. The results of these studies suggest that the amygdala may support ToM development through its connections with other brains areas, specifically the prefrontal cortex. When this connection is disrupted early in life, either due to brain damage or to neurodevelopmental disorders, ToM understanding is negatively affected.

The finding that ToM abilities are sub-served by a number of different brain systems supports the notion that ToM is not a unitary concept but consists of a number of different components. The fractionation of ToM is supported by the finding that different ToM abilities are acquired at various stages in neural system development.

CHAPTER II: DEVELOPMENT OF THEORY OF MIND

Based on the research discussed in the previous section, it would seem reasonable to assume that each step in the development of ToM understanding may reflect the development of underlying neural mechanisms supporting mentalizing, particularly the maturation of the frontal lobes and the connectivity between the frontal cortex and limbic areas. Children develop ToM abilities through a series of discrete stages. A number of different precursors to ToM have been proposed, each emphasizing different aspects of child development. These different theories include how children learn to distinguish between agents and objects, the importance of eye gaze, pretend play, and finally the progression from desire (e.g., Mary *wants* the crayons) to belief (e.g., Mary *thinks* the crayons are in the cupboard) understanding.

Agents versus Objects

Long before children learn to attribute internal states to humans, they must first be able to distinguish people from objects. This ability is the first step in the development of social cognition (see Frith & Frith, 2003 for a review). Two-week-old infants prefer to look at stimuli that resemble faces (Valenza, Simion, Cassia, & Umilta, 1996) and smile more often toward people than toward objects (Legerstee, 1992). Around the same time, infants begin to imitate facial expressions (Meltzoff & Gopnick, 1993; Meltzoff & Moore, 1977) and, when given the opportunity to imitate either the actions of humans or similar actions performed by objects, infants copy humans (Legerstee, 1991). Based on these and similar findings, researchers have suggested that from birth, humans prefer to interact with conspecifics, and this provides the basis for the understanding of intentional action and later ToM understanding (Meltzoff & Moore, 1977).

After infants learn to distinguish *between* people and objects they begin to understand the ways in which humans *act upon* objects. Researchers have investigated this ability by using the preferential-looking paradigm, a clever method that takes advantage of the fact that infants will pay more attention to a novel stimulus or behaviour than to a familiar stimulus or behaviour. Woodward (1998) conducted a study in which she habituated six-month-old infants to a particular action: an experimenter reaching and grabbing one of two objects. After the infants were habituated, they were exposed to one of two test conditions: either the experimenter reached for a non-target object or changed the direction in which he or she reached for the target. These infants preferred to look at the experimenter grabbing the new object, leading the authors to suggest that young infants interpret human reaching movements as goal-directed.

After the first year of life, infants move beyond the simple understanding that reaching and grasping behaviours are goal-directed to an understanding that people have psychological states such as intentions that can influence one's action (Phillips & Wellman, 2005). In research conducted by Phillips and colleagues (2005), an experimenter looked toward one of two objects expressing a positive emotion. The experimenter then either grabbed the object that he or she was looking at, or grabbed an alternative object. One-year-old infants tended to pay more attention to the experimenter when he or she grabbed the object they were not looking at, thus suggesting that this response contradicted the infants' expectations. Therefore, even infants as young as 12 months of age recognize people as intentional actors. In support of this view, Meltzoff (1995) found that when 18-month-old infants saw an actor attempt, but fail, an intentional act (e.g., attempting to push a device through an open hole), these infants were able to complete the action the actor intended to do. Baron-Cohen (1995) has proposed that recognizing intentional action is one of the most important precursors for developing ToM, and coined the term 'intentionality detector' to describe this ability. Importantly, infant understanding of intentional action predicts later ToM functioning (Aschersleben, Hofer, & Jovanic, 2008; Wellman, Phillips, Dunphy-Lelii, & LaLonde, 2004; Wellman, Lopez, LaBounty, & Hamilton, 2008).

The neural systems underlying the preference for facial stimuli and the ability to recognize goal-directed and intentional actions are difficult to assess in infants due to limitations in conducting neuroimaging studies on extremely young participants. However, ToM researchers have suggested that these abilities are based on the maturation of certain brain systems known to support these functions in adults (see Frith & Frith, 2003, for a review). The preference for human facial stimuli has been linked to activity in the temporal cortex, specifically the fusiform gyrus, in adults (see Frith & Frith, 2003, for a review). The ability to recognize goal-directed and intentional action has been found to increase activity in the superior temporal sulcus (STS). Additionally, when participants view human goal-directed movements versus similar actions performed by machines, there is also a significant increase in activation in the prefrontal cortex (Carter, Hodgins, & Rakinson, 2011). Frith and Frith (2003) have suggested that the infant's preference for social stimuli such as human facial expressions and the ability to recognize goal-directed and intentional actions is based on the maturation of temporal and frontal regions of the brain, areas known to be involved in ToM.

Eye-Gaze Detection

Another important precursor to ToM is the ability to detect the direction of eye gaze (Baron-Cohen, 1995). Infants as young as two months of age prefer to look at the eyes over and above the mouth, nose, and other features (Maurer & Salapatek, 1976). Importantly, infants can track the direction of eye gaze even when the head remains motionless (Hood, Willen, & Driver, 1998). Alternatively, infants *do not* follow head movements when the eyes are closed (Brooks & Meltzoff, 2002) and do not follow eye-gaze when an individual's field of view is occluded, suggesting that they are able to comprehend that the actor cannot see that object (Dunphy-Lelii & Wellman, 2000). Following eye gaze is important because it is how infants learn to link objects with intentions (i.e., they learn that what another person is looking at is what they are attending or referring to). Baron-Cohen (1995) included the ability to follow another person's eye gaze in his list of precursors to ToM, creating the term the Eye-Direction-Detector (EDD) to reflect this ability. In his theory, the EDD is important for three reasons: "it detects the presence of eyes or eye-like stimuli, it computes whether eyes are directed toward it or toward something else, and it infers from its own case that if another organism's eyes are directed at something then that organism sees that thing" (p. 38-39).

The EDD is what sets the stage for joint attention, or what Baron-Cohen (1995) refers to as the Shared-Attention Mechanism (SAM)–a three-way relationship between the individual, another person and an object. While the EDD allows infants to realize that another person is looking at something, joint attention allows the child to realize that another person sees what they see. The development of joint attention coincides with the appearance of protodeclarative pointing, in which an infant uses pointing gestures to draw another person's attention to an object. Joint attention is an important precursor to ToM because young children can infer mental states based on eye gaze direction (Baron-Cohen, 1995). For example, mommy is looking at the cereal, therefore mommy *wants* cereal. There is evidence that even 1-year-old infants expect an adult to pick up or act upon the object that he or she was looking at (Phillips *et al*., 2005). Importantly, an infant's ability to engage in joint attention predicts later ToM understanding (Charman, Baron-Cohen, Swettenham, Baird, Cox, & Drew, 2000).

Further evidence supporting the assertion that both eye gaze detection and joint attention are precursors to ToM understanding is based on the finding that autistic individuals display substantial deficits in both abilities (Charman, Swettenham, Baron-Cohen, Cox, Baird, & Drew, 1997; Mundy, Sigman, & Kasari, 1990). For example, while healthy individuals look towards the eye region of the face for information about an individual's mental state during social interactions, individuals with autism tend to ignore this vital area and fail to make direct eye contact (Barbaro & Dissanayake, 2012). In addition, research has found that during joint attention tasks, autistic individuals alternate eye gaze between an experimenter and a stimulus less often than non-autistic participants (Charman *et al*., 1997). Goldberg and colleagues (2002) have proposed that deficits in the ability to switch eye gaze observed in autism are due to oculo-motor disturbances, possibly stemming from abnormal neurodevelopment of the prefrontal cortex and the frontal eye fields. Additionally, research has shown that the neural substrates supporting joint attention are similar to the brain areas supporting ToM functioning, specifically the ventromedial prefrontal cortex (Williams, Waiter, Perra, Perrett, & Whiten, 2005). These findings further support the notion that ToM understanding is based on the development of several brain areas, particularly the frontal lobes, and that when neural development goes awry, ToM understanding is negatively affected.

Pretend Play and Conflicting Mental Representations

By the age of two, children begin to engage in pretend play which, according to Leslie (1987), is an important developmental precursor to ToM. Everyone has a representation of the world–an individual's mental picture including perceptions and beliefs. An individual's mental representation is not an exact imprint of the world, but rather is an interpretation (Leslie, 1987). 'Metarepresentation' refers to the ability to represent another person's representation. This ability is key to pretend play because–as in Leslie's (1987, p.414) example–when a child's friend picks up a banana and pretends that it's a telephone, the child can separate the real life representation of the object (e.g., banana) from the pretend representation of the object (e.g., telephone). Leslie (1987) uses the term 'decoupling' to refer to the child's ability to separate pretend from reality, and without this ability children would confuse the characteristics of objects, such as not understanding why he or she cannot pick up a banana and call mom. Youngblade and Dunn (1995) found that children who frequently engaged in pretend play scored higher on ToM measures one year later.

The metarepresentational abilities required for pretend play are similar to children's ability to differentiate between the properties of real versus imagined objects (Wellman & Estes, 1986). Three-year-old children understand that real objects can be touched and manipulated and that other people can see these objects. On the other hand, imagined objects cannot be readily examined, exist only in the mind of the imaginer and are temporary representations. This distinction is important for ToM development because similar to pretend play, it helps children to differentiate between mental representations of the world and how the world actually exists (Wellman & Estes, 1986).

After children understand that a representation can be different from reality, they can also appreciate that individuals can hold conflicting representations. This ability has been assessed using a level 1 perspective-taking task (Flavell, Everett, Croft, & Favell, 1981). In this experiment, a folded card with a different picture on each side is placed between the child and the experimenter and the child is asked to state not only what he or she can see but also what the experimenter can see. Three-year-old children are able to recognize that the experimenter's perspective is different from their own, even though they are both looking at the same object. Children's developing ability to understand alternative representations is a precursor for the ability to recognize that individuals can hold false beliefs about the world.

The above research describes the ability to hold two different representations in mind, and it has been suggested that this ability is subserved by a specific region of the medial prefrontal cortex, the anterior paracingulate gyrus (Frith & Frith, 1999; Gallager *et al*., 2003). The finding that by the time children are two years of age they engage in pretend play is interesting given the fact that the first two years of life is an important time in cortical development involving substantial increases in gray and white matter volume (Knickmeyer, Gouttard, Kang, Evans, Wilber, Smith, *et al*., 2008). It is worth noting that autistic children–a population shown to have impairments in social understanding–have enlarged brains, including an unusual amount of white and grey matter compared to healthy children (Chourchesne, Kams, Davis, Ziccardi, Carper, Tigue *et al*., 2001), and this has been found in areas including the cingulate cortex and the temporal lobes (Hua, Thompson, Leow, Madsen, Caplan, Algerm, *et al.,* 2011). Knickmeyer and colleagues (2008) have suggested that this may be due to “an exaggeration of normal developmental processes in the first two years of life, such as synaptic proliferation and myelination” (p.12180). This abnormal cortical development, including both atypical connectivity between brain regions due to aberrant white matter development and enlarged grey matter, may be one of the reasons why autistic individuals show disturbances in social understanding. This assertion is supported by the fact that two-year-old autistic children participate in pretend play far less often than healthy children (Charman *et al*., 1997).

Desire-Based Versus Belief-Based Understanding

Wellman and Wooley (1990) have proposed that children first come to understand human action in terms of desires–they later understand that beliefs can affect behaviour. Two-year-old children’s understanding of desire is first reflected in their vocabulary with the use of terms such as ‘want’ or ‘like’ (Bartsch & Wellman, 1989; Dunn, Bretheron & Munn, 1987). Similarly, at this age children can predict action based on a person’s desire, such as if a person desires an object, that individual will not only look for the item, but will continue to search until it is found (Wellman and Wooley, 1990). Children this age also have a basic understanding of emotions and use terms referring to feeling states such as ‘sad’, ‘happy’, or ‘scared’ (Bretheron & Beeghly, 1982). Two-year-old children are able to identify sad, happy, angry, and fearful facial expressions and can also predict how a character would feel following different emotional scenarios, such as being afraid following a bad dream (Denham, 1986). In relation to the concept of desire, children understand that an individual's emotional reaction will depend on whether the individual obtains the desired object. For example, if John has been looking for his teddy bear and he locates it, he will be happy; if he does not find it, he will be sad (Wellman & Wooley, 1990).

At three years of age, there is an important transition in ToM development from a desire-based ToM to one that ascribes a larger role to belief (Wellman & Bartsch, 1988; Bartsch & Wellman, 1989). This change is first reflected in children's utterances in which 3-year-olds begin to use cognitive terms such as 'know' or 'think' (Brown & Dunn, 1991). Wellman and Barstch (1988) were among the first researchers to test whether 3-year-old children could take into account a character's belief when predicting his or her behaviour. In their paradigm, participants were read a story in which the protagonist wanted a marker that could be found in *either* a drawer or a cupboard; however, the protagonist thought the object was only in one location (in the drawer). Three-year-old children were able to accurately predict that the protagonist would look only in the location that corresponded to his or her belief.

For a number of years it was believed that the most important ability in ToM development was false belief recognition (Dennett, 1978). False belief understanding entails the capacity to recognize that someone else's belief is not only different from one's own belief, but is also disparate from reality. False belief measures are considered to be the 'gold standard' of ToM assessment. Dennett (1978) has argued that once children are able to pass such tasks they have fully acquired a 'theory of mind'. Typically, children are not able to pass false belief tasks until they are approximately four years of age (Wimmer and Perner, 1983; Hogrefe, Wimmer, & Perner, 1986; Perner, Leekham & Wimmer, 1987; Wellman & Bartsch, 1988; Baron-Cohen, 1985). Four-year-old children's ability to predict human behaviour based on both desires and beliefs is a result of healthy frontal lobe functioning (Frith & Frith, 1999; Gallagher *et al*., 2003). Therefore, it is reasonable to assume that young children's inability to engage in belief-desire reasoning may be due to the fact that the neural areas involved with ToM reasoning, especially frontal areas, are not yet mature enough to support this understanding.

After children are able to recognize false beliefs, they begin to understand complicated emotions such as surprise or embarrassment (Hadwin & Perner, 1991; Ruffman & Keenan, 1996). According to Harris and colleagues (1989), 'sad' and 'happy' are "desire-based" (p.216) emotions because obtaining something desired will lead to happiness while failure to obtain something desired will result in sadness. Alternatively, Ruffman and colleagues (1996) describe surprise is a "belief-based" (p. 41) emotion because it occurs only when one's belief about the world is different from reality. Therefore, in order to recognize 'surprised', an individual must first be able to recognize a false belief. In fact, researchers have found that children first understand the concept of false belief before they can accurately identify belief-based emotions such as surprise (Hadwin & Perner, 1991; Bradmetz & Schneider, 1999).

Embarrassment is also considered a more complicated emotion than sad or happy. This is due to the fact that recognizing when an individual is embarrassed requires perspective-taking skills–the ability to understand that the person who has committed the embarrassing act is experiencing a negative emotional reaction because surrounding individuals have viewed that act as socially inappropriate (Lewis, 1995). Previous research has found that while individuals with autism are able to accurately predict emotions caused by situational factors such as sadness or happiness, participants failed to accurately assess belief-based emotions (Baron-Cohen *et al*.,1991) and performed poorly on tasks assessing 'awkward moments' (Heavy, Phillips, Baron-Cohen, & Rutter, 2003). Similarly, when asked to explain why a particular situation may be embarrassing, individuals with autism gave more incorrect answers when compared to controls (Hillier & Allison, 2002). This research suggests that recognizing belief-based emotions such as embarrassment is more difficult than recognizing simple emotions such as sad or happy.

The above research suggests that ToM can be divided into a number of different components such as the capacity to distinguish between agents and objects, the use of eye-gaze information, and pretend play. Regardless of the way in which children acquire ToM abilities, a child is believed to have acquired ToM when he or she can pass false belief tasks. The discovery that children are unable to pass such tasks before four years of age is a stable finding across studies. These results are obtained even when researchers manipulate the experimental technique (Perner *et al*., 1987; Perner *et al*., 1989; Wellman, & Bartsch, 1988), and when other variables such as memory and IQ are controlled (Perner *et al*., 1987). The next section will review the common measures used to assess children's ToM understanding. Later, I will entertain the notion that ToM abilities do not culminate in false belief understanding but instead continue to develop into the adolescent and adult years, directly coinciding with the maturation of the late-forming frontal lobes.

CHAPTER III: THEORY OF MIND MEASURES

First-Order False-Belief Tasks

Wimmer and Perner (1983) were the first researchers to assess false belief reasoning in children. In their experiment, participants were read a story in which the protagonist, Maxi, places his chocolate in a cupboard and then leaves. Unbeknownst to Maxi, his mother moves the chocolate from the cupboard into a different location. Participants were then asked the question, "Where will Maxi look for his chocolate?" (p.109). Baron-Cohen (1985) developed a very similar paradigm using two different toy dolls to act out a scenario. In this story, Sally has a marble and leaves the marble in a basket. After Sally leaves, her friend Anne enters the room and surreptitiously removes the marble from the basket, places it into box and then leaves. Once Sally has returned, participants are asked, "Where will Sally look for her marble?" (p. 41). Children under the age of four typically fail these tasks by reporting that Sally will look for her marble in the box instead of in the basket. In other words young children report their own belief, rather than the character's false belief.

Perner and colleagues (1987, 1989) commented that the reason young children may not be able to pass the false belief tasks developed by Wimmer and Perner (1983) and Baron-Cohen (1985) is because the scenarios are too difficult for children to understand. Perner *et al*. (1987, 1989) hypothesized that if children experience the same sequence of events as the story's protagonist in a false belief paradigm, they would not only be able to recognize their own false belief, but be able to understand the protagonist's false belief as well. In this task, children were shown a candy box (e.g., Smarties) and were asked what they thought the box contained. After the children indicated that they thought candy was inside the container, they were shown that the box actually held pencils. After the experimenter closed the carton, the child's friend was brought into the room and participants were asked what his or her friend would think was within the box. Three-year-old children consistently stated that their friend thought the carton contained pencils, while older children recognized the friend's false belief. Even children who were able to recognize their own previous incorrect belief were unable to pass this task.

Advanced Theory of Mind Measures

Second-Order False Belief Tasks

In the past, it was thought that successfully completing a false belief experiment is the marker of ToM understanding (Dennett, 1978). Other researchers, however, have challenged this assertion and instead have claimed that mentalizing abilities continue to develop well into the adolescent years (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999). In order to assess development beyond five years of age–the age at which all typically developing children pass false belief tasks–researchers have created advanced ToM measures. One of these measures is the second-order false belief task, which taps the capacity to represent a 'belief about a belief' (Perner & Wimmer, 1985). One of the first experiments designed to assess this ability was developed by Perner and Wimmer (1985). In their paradigm, two characters, John and Mary, go to a park to buy ice cream. Mary realizes that she has forgotten her money and returns home to get it, while John remains with the ice cream truck. After a little while, John decides to return home but not before seeing the ice cream truck move to a different location.

Unbeknownst to John, Mary also sees the ice cream truck move from location A to location B. After the story is read to the participants, they are asked where John thinks Mary will go to buy her ice cream. Four- and five-year-old children incorrectly stated that John thinks that Mary will go to location B. Only children six and seven years of age were able to understand that John thinks that Mary will return to location A. Therefore, while four-year-old children understand false beliefs, six-year-old children have the additional capacity to understand beliefs about other individual's beliefs.

Faux Pas Recognition Test

Baron-Cohen and colleagues (1999) were the first researchers to design a measure aimed at assessing ToM abilities in adolescents. Their test examines the ability to detect a faux pas, which the researchers define as, "... when a speaker says something without considering if it is something that the listener might not want to hear or know, which typically has negative consequences that the speaker never intended" (p. 408). Consider one of the faux pas stories used in their experiment:

> "Jeanette bought her friend, Anne, a crystal bowl for a wedding gift. Anne had a big wedding and there were a lot of presents to keep track of. About a year later, Jeanette was over one night at Anne's for dinner. Jeanette dropped a wine bottle by accident on the crystal bowl and the bowl shattered. "I'm really sorry. I've broken the bowl," said Jeanette. "Don't worry," said Anne. "I never liked it anyway. Someone gave it to me for my wedding." (p. 416)

In this example, Anne committed a faux pas by unintentionally insulting Jeanette's gift. Although the comment was accidental, it would have resulted in Jeanette feeling upset or hurt. One of the reasons why the faux pas recognition test is considered an advanced mentalizing task is because it assesses both cognitive and affective ToM capabilities. Detecting a faux pas requires recognizing that the characters in the story have different beliefs or thoughts, and that the statement had a negative emotional impact on one of the characters. This test has been used to assess ToM abilities in both adults and adolescents; however, children are not able to score well on this task until they are 9-11 years of age due to the advanced social complexities embedded within the task (i.e., recognizing differing beliefs *and* affective states).

Reading the Mind in the Eyes Task

Another task that is used to assess ToM abilities in adolescents and adults is the Reading the Mind in the Eyes task (RME). This task requires participants to make mental state attributions based on visual/perceptual information–a picture of the eyes. This task was developed in order to detect subtle ToM disturbances (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). For example, while individuals with Asperger's syndrome (a milder form of autism) pass traditional ToM measures such as the first-order false belief task, they typically fail higher-order measures such as the RME (Baron-Cohen *et al*., 1997). In this task, participants are shown a picture of the eye region of the face and have to choose which mental state the eyes are expressing. For example, one experimental trial could include the options 'concerned', 'thoughtful', 'playful' or 'upset'. What is unique and difficult about this task is that participants make their responses based on very limited information (i.e., just the eyes), while previous ToM measures included entire facial expressions (Denham, 1986). Individuals who fail this task are unable to appreciate or recognize the significant role that eyes have in expressing internal states. This task expands on and stresses the importance of one particular component of ToM – the ability to recognize the direction of eye gaze and the capacity to use this information to infer goals and intentions. Children who fail to use eye gaze information to infer intentions will most likely fail the RME task later in adulthood (Baron-Cohen *et al*., 1997).

The ToM tasks described above are aimed at assessing advanced ToM understanding in adolescents and adults. It is clear from the above descriptions that these measures are verbally based. The second-order false belief task and the faux pas recognition test require participants to extract mental state information from a narrative and to give verbal responses. The RME task is slightly different in the sense that the participant has to translate an image into a corresponding verbal label, often involving words that require an advanced vocabulary. The relationship between language and ToM understanding is discussed below.

CHAPTER IV: LANGUAGE AND THEORY OF MIND

Language is important for ToM because it allows one to learn about concepts that are not readily visible. For example, Miller (2006) has stated that children learn what the word ‘skate’ means simply by observing that behaviour; however, a child cannot see what is to ‘think’, ‘know’, or ‘want’ (pg. 145). These mental concepts are specifically learned through language and linguistic experiences (see Miller, 2006, for a review). Language also allows the separation of reality from mental states such as beliefs, thoughts, or dispositions (Astington & Baird, 2005). Consider the sentence “John thinks that Mary is outside". In this example, language can be used to decouple reality (i.e., Mary is outside) from dispositions or thoughts (i.e., John 'thinks'). Astington and Baird (2005, p.164) described the difference between perceptual real-life experiences and linguistic representations by stating that seeing rain outside is coupled with the belief that it is raining. However, the statement "it is raining" is not necessarily true due to the fact that language may be used to convey sarcasm through aspects such as changing the tone of one's voice (Astington & Baird, 2005). Unlike perceptual experiences, language conveys information by simply re-arranging the words in a sentence or speaking with a particular intonation. In this sense, language can be used to accurately represent or contradict reality. Similarly, ToM understanding encompasses the ability to separate a mental representation from reality when someone has a false belief (Astington & Baird, 2005).

The theories noted above imply that language provides the foundation for ToM understanding. Although most researchers would agree that language and ToM are related in some way, the nature of the relationship is controversial. Some researchers have suggested that ToM abilities are dependent upon and supported by language (Astington & Jenkins, 1995; de Villiers and de Villiers, 2000; de Villiers & Pyers, 2002; Moore, Pure, & Furrow, 1990; Ruffman, Slade, Rowlandson, Rumsey, & Garnham, 2003), while others have argued that language and ToM understanding are independent and that ToM abilities do not rely on linguistic competence (Bloom & German, 2000; Chandler, Fritz, & Hala, 1989; Fordor, 1992; Lewis & Osbourne, 1990; Leslie, 1987). The following section will report research supporting the former.

Language is Important for ToM Understanding

One question that arises in regards to language and ToM is which aspects of language are critical to false belief understanding? The word ‘language’ encompasses numerous characteristics including semantics and syntax, both of which have been found by different researchers to play an important role in ToM (see Miller, 2006 for a review). Semantics refers to word definitions and researchers have suggested that learning the meaning of mental state words such as ‘know’ or ‘think’ is important for predicting an object's location (Moore *et al*., 1990). Moore and colleagues (1990) conducted a study in which the experimenters put an object in one of two possible locations and asked four-year-old children to choose which location they thought the object would be in based on the clues “It *must* be in the red box” or “It *could* be in the blue box” (p.724). The authors found that children’s ability to distinguish between the terms ‘must’, ‘might’, and ‘could’, and to use this ability to correctly point out the object’s location, was significantly related to performance on false-belief tasks.

Other researchers have stressed the importance of syntactic understanding in ToM. Syntax refers to the structural components of language including grammatical rules to link words into sentences and the understanding that differences in word order can alter the meaning of a sentence. Astington and Jenkins (1995) conducted a longitudinal study investigating the relation between syntactic and semantic abilities and false-belief understanding in 3-year-olds. The researchers found that language capabilities, particularly syntax, predicted later ToM understanding. These authors suggest that the ability for children to recognize and understand that word order plays a significant role in sentence meaning may be similar to their mental ability to keep track of an object’s change in location from point A to point B (unbeknownst to the story protagonist) in false-belief tasks. de Villiers and de Villiers (2000) provide a specific description of the importance of syntax in false belief understanding. In their example, the authors break down elements of the sentence “Mary thinks that the candy is in the drawer” (p.93). The proposition “the candy is in the drawer” may not be true in reality, but the entire sentence of “Mary thinks that the candy is in the drawer” is true even though the candy may be elsewhere. Therefore, learning sentence structure may provide the foundation for a child to be able to represent two alternative representations, their own and another person’s (de Villiers & de Villiers, 2000).

One of the potential confounds of the studies listed above is that in order to understand syntax, one must also understand the meaning of the individual words in the sentence (Ruffman *et al*., 2003). Ruffman and colleagues (2003) attempted to elucidate the independent roles that semantic and syntactic competence play in ToM understanding. In order to assess syntactic ability participants were given the sentence “The mouse is under the chair” (p.155) and had to choose which of three pictures correctly represented this statement. Semantic ability was examined in a way that placed fewer demands on syntactic understanding. Participants were presented with the statement “He will eat the apple” and were then shown three different pictures including “a man walking away from an apple, a man holding an apple in front of his face, and a man with an eaten apple on his plate” (p.142). The authors argued that their test of syntactic ability places a higher demand on understanding word order than on traditional language tests. The researchers found that syntactic understanding did not significantly predict ToM scores over and above semantic understanding. These researchers came to the conclusion that general language ability, including a combination of both syntax and semantics, significantly predicts ToM performance. Therefore, although these results support the notion that language is related to ToM, specific aspects of language do not contribute independently to ToM understanding.

Other research that supports the notion that language aids ToM development is from studies that assess young children's conversational discourse. Two-year-old children who frequently participated in conversations with their family members about emotions and the causes of human behaviour outperformed children who did not have these conversational experiences on affective labelling, affective perspective-taking, and false-belief tasks nearly seven months later (Dunn, Brown, Slomkowski, Tesla, & Youngblade, 1991). Additionally, Hughes and Dunn (1998) found that these conversations are not limited to family members because children who participate in mental state talk with their friends perform higher on ToM tasks than children who engage in mental state talk less frequently. These differences indicate that it may not be the context in which the conversation occurs that is important, but just the frequency with which children are participating in mental state talk. This suggests that conversational experiences are an important way for children to learn about mental states and the behaviours that result from them.

Pragmatic ability refers to the correct or appropriate use of language and gestures in social situations such as staying on topic while speaking to another person, re-explaining topics of conversation when the listener has misunderstood, taking turns during conversation, looking at the listener's eyes while speaking, and so forth (Bates, 1976). While pragmatic ability is not necessarily a linguistic process such as understanding word meaning or syntax, it is nonetheless important in order for individuals to engage effectively in social interactions. Aspects such as re-explaining misunderstood topics directly relates to ToM capabilities because the speaker has to be able to recognize that the listener's thoughts are different from one's own. Therefore, pragmatic and ToM abilities are fundamentally connected; if an individual lacks ToM abilities, he or she will most likely show deficits in pragmatic ability as well (Baron-Cohen, 1988). In support of this view, autistic individuals display severe disturbances in pragmatic abilities, while at the same time performing poorly on ToM measures (Baron-Cohen, 1988).

The above research suggests that language and ToM are fundamentally intertwined; the strongest assertion is that general language ability allows for ToM understanding. However, current tools used to assess ToM are linguistically complex and this may be the reason why researchers have found such strong correlations between the two abilities.

Is Linguistic Competence Required for ToM Understanding?

If ToM understanding is dependent upon language then it would seem reasonable to assume that there is overlap in the neural systems supporting language and ToM reasoning. While there are commonalities in the brain areas that are active in response to both linguistic and mentalizing tasks, such as increased temporal lobe activity, there are differences as well. The primary brain areas that have been shown to be involved in language processes include the inferior frontal cortex and the superior temporal gyrus including Broca's area and Wernicke's area (for a review, see Hickok, 2009). The neural substrates of ToM include the orbitofrontal cortex, the cingulate cortex, the superior temporal sulcus, the temporal poles, and the amygdala (Gallagher & Frith, 2003). In fact, Gallagher and Frith (2003) have suggested that the ability to reason about counterfactual information in false belief tasks is supported by a specific area in the frontal lobe, the anterior paracingulate cortex, an area typically not involved in language. Further support for the notion that there are differences in the neural networks involved in language and ToM comes from studies investigating lateralized activity. While language is supported by the left hemisphere, lesion studies have found that left hemisphere damage does not disrupt ToM reasoning. However, patients with damage to the right hemisphere perform poorly on ToM tasks (Siegal, Carrington, & Radel, 1996). The differences in the neural networks supporting language and ToM may suggest that ToM functioning is not completely reliant on linguistic abilities.

Further support for the idea that there are differences in the neural systems supporting ToM and language comes from two studies with aphasia patients who suffered extensive damage to the left temporal cortex (Varley & Siegal, 2000; Varley, Siegal, & Want, 2001). Patient S.A. suffered from agrammatic aphasia. Varley and Siegal (2000) describes this patient's difficulties: "He showed no evidence of an ability to formulate propositions in speech or writing. He was not able to make judgements as to whether a sentence was grammatical, or to match sentences to pictures, or to identify the meaning of verbs" (p.723). Although patient S.A presented with extreme linguistic difficulties he passed a first-order ToM task. Varley and colleagues (2001) later replicated this finding with another agrammatic aphasic patient whose disability was more severe then patient S.A. What these two studies suggest is that ToM understanding is not completely dependent on linguistic competence; instead, individuals with severe linguistic disturbances still demonstrate mentalizing capabilities.

Problems With Current ToM Measures

When considering the correlations found between ToM and language, it is important to consider the types of measures that researchers use in order to assess ToM understanding. The majority of the tasks outlined in the previous section are highly dependent on both expressive (i.e., the ability to verbally communicate one's own ideas and thoughts) and receptive (i.e., the ability to recognize what is being said) language abilities. In ToM measures such as the false belief tasks and the Faux Pas Recognition Test, participants are read short vignettes and are then asked a series of questions based on the story's premise such as "Did someone say something that was inappropriate?" or "Where will Maxi look for her chocolate?". In order for participants to perform well on such tasks, they must be able to understand the detailed narrative, comprehend the questions being asked by the experimenter, and respond verbally. Clearly these measures place high demands on verbal skills. Even the Reading the Mind in the Eyes Task, which is considered a perceptual or visually based assessment, is highly dependent on the participant's vocabulary; it would be impossible for a participant to perform well on this task without a glossary of mental state terms (e.g., contemplative, despondent, incredulous, sympathetic). Baron-Cohen (2001) mentions this aspect in his article: "A task analysis of the Eyes Test might include the following: The subject needs to have a mental state lexicon and know the semantics of these terms. The Eyes Test then involves mapping these terms to fragments of facial expressions of mental states–just the part of the face around the eyes" (p.241).

The primary concern surrounding current ToM measures is whether they are truly assessing conceptual ToM understanding or, because of the requirements of the tasks, are actually assessing linguistic comprehension. It has been suggested that current ToM measures place high demands on linguistic competence and that this may be the reason why previous research has reported strong correlations between language and ToM performance (Chandler, 1989; Lewis & Osbourne, 1990). Saxe (2004) has stated that these correlations may actually be due to that fact that four- to five-year-old children undergo a substantial increase in linguistic development and therefore are able to verbally express their ideas about the mental states of others. However, it is possible that younger children, 2-3 years of age, possess a fledging ToM but because of their rudimentary linguistic skills are unable to verbally express it. Therefore, current ToM measures may underestimate young children's ability to entertain false beliefs.

Support for the premise that current ToM measures mask underlying abilities to reason about counterfactual beliefs comes from experiments that have altered the experimental tasks in order to decrease linguistic demands (Chandler *et al*., 1989; Lewis & Osbourne, 1990). Chandler and colleagues (1989) conducted a study investigating young children's ability to deceive by intentionally imputing a false belief in another experimenter. What is unique about deception tasks is that in order to successfully deceive another individual, the participant must be able to purposefully manipulate a situation in a way that would lead others to have a false belief. If children are able to accomplish this, then they must possess some aspects of ToM. Interestingly, Chandler and colleagues (1989) found that children as young as two years old were able to purposefully deceive another individual, leading the researchers to conclude that contrary to prior theories, young children have a basic understanding of the concept of false belief. These results coincide with the findings of Lewis and Osborne (1990) who investigated whether young children may simply misunderstand the questions posed to them during false belief tasks. These researchers implemented a change-content Smarties™ task (i.e., unbeknownst to the story protagonist, the Smartie's box contained pencils rather than candy), and altered one significant aspect of the experiment: rather than asking "What did John think was inside the box?" the experiments asked "What did John think was inside the box *before* I took the top off?"(p.1516). By simply adding the *before* clause to the questions, three-year-old children were able to successfully complete the false belief task. The authors suggest that the word 'before' allowed the children to understand the exact period of time the experimenter was referring to and thus they were able to answer the questions accurately.

What the research reviewed here suggests is that current measures of ToM ability are linguistically complex and may not be assessing true mentalizing skills. The reliance on verbal-based ToM tasks is alarming because, as previously stated, current measures may mask young children's true ability to reason about false beliefs. This aspect is important to consider when examining ToM abilities in clinical populations as well. A number of clinical groups with language disturbances may appear to have mentalizing abnormalities, but in actuality, they may be failing because existing ToM tests are dependent on verbal skill. In order to elucidate the true relationship between language and ToM, novel measures have to be developed that place less emphasis on verbal abilities. The current research will address this issue by creating two non-verbal ToM measures.

Another area in which ToM research is lacking is the number of measures that centre on emotional understanding. The majority of existing assessments focus on cognitive aspects of ToM such as recognizing false beliefs. However, emotion recognition is also an important part of recognizing and predicting human action. The current study will expand on extant research by creating two affective non-verbal ToM measures.

CHAPTER V: COGNITIVE VERSUS AFFECTIVE THEORY OF MIND

Researchers have suggested that ToM understanding can be broken down into affective and cognitive components, what Brothers and Ring (1992) refer to as 'hot' and 'cold' aspects of ToM, respectively. Cognitive aspects of ToM include making judgements about the thoughts, intentions or beliefs of other people, while affective components refer to the recognition of emotional states. This differentiation is supported by the findings that both cognitive and affective aspects are supported by overlapping but also distinct brain areas. Patients with damage to the ventromedial prefrontal cortex pass first- and second-order false belief tasks but fail faux pas recognition tests (Shamay-Tsoory, Tomer, Berger, Goldsher, Aharon-Peterz, 2005; Shamay-Tsoory, Tibi-Elihanany, & Aharon-Petetz, 2006). This pattern suggests that the ventromedial PFC may play a special role in affective theory of mind, and more specifically in integrating the affective and cognitive information that is required in order to recognize a faux pas. This assertion is reasonable considering that the ventromedial PFC has connections to limbic areas of the brain.

Given the fact that ToM understanding can be differentiated between cognitive and affective components, it is surprising that the majority of current ToM measures ignore affective understanding; there are more measures assessing cognitive than emotional ToM. This discrepancy is an issue because current ToM measures are, therefore, not fully assessing all aspects of ToM. Clearly individuals interpret and predict human behaviour on the basis of emotions rather than just on thoughts or beliefs. Even young infants are able to accurately predict intentional actions based on emotional facial expressions (Phillips & Wellman, 2005). In fact the majority of ToM measures present participants with either pictures of faces (Denham, 1986) or eyes (Baron-Cohen, 2001) depicting different emotions. Although affective labelling tasks have been shown to be related to more advanced ToM tests, such as predicting a person's action based on their facial expressions (Brune, 2005; Henry, 2006; Mier, Lis, Neuthe, Sauer, Eslinger, Gallhofer, *et al*., 2010), individuals use additional information in order to explain and predict human behaviour. Sommer and colleagues (Sommer, Dohnel, Meinhardt, and Hajak, 2008) commented that individuals use *both* emotional facial expression *and* context when making behaviour predictions. However, the majority of affective ToM tests have relied solely on emotional expressions and have ignored context. The current study addressed this issue by creating two affective ToM measures that incorporate both of these factors, and are therefore more naturalistic assessments of this ability.

The creation of affective ToM tasks is vital in order to fill in a major gap in current ToM research; however, it is also important to assess whether there are performance differences between males and females on affective ToM tasks. A number of studies investigating ToM have found a female advantage in mentalizing ability

(Baron-Cohen *et al*., 1999; Baron-Cohen *et al*., 2001). Unfortunately, the majority of ToM tasks that were used in these studies assessed cognitive and not affective ToM. The next section will discuss the idea that males and females utilize different strategies when completing ToM tasks, possibly resulting in females being more adept at recognizing and interpreting affective ToM compared to males.

CHAPTER VI: SEX DIFFERENCES IN THEORY OF MIND REASONING

Several studies have reported sex differences in mentalizing abilities. In healthy adults, previous research has found that females score higher than males on the Reading the Mind in the Eyes task (Baron-Cohen *et al*.,1997, 2001) and on the Faux Pas Recognition Test (Baron-Cohen *et al*.,1999). Sex differences have also been reported in young children, with girls showing an advantage over boys on tasks requiring the ability to recognize and label emotional states (Bosacki, 2000; Dunn *et al*.,1991), and false belief tasks (Happe, 1995). Baron-Cohen (2002) has suggested that one of the reasons that females tend to score higher than males on ToM assessments is because of their greater ability to 'empathize' (Baron-Cohen & Wheelwright, 2004). Empathy is defined as the "... drive to identify another person's emotion and thoughts and to respond to these with an appropriate emotion" (Baron-Cohen, 2002, p. 248). By definition, empathy can be divided into cognitive and affective components. Cognitive aspects of empathy refer to ToM abilities such as making judgements about other individual's thoughts or perspectives, while affective empathy is when an individual views the emotional state of another person and then experiences a similar affective response (Baron-Cohen & Wheelwright, 2004).

There is another theory which attempts to explain sex differences in ToM reasoning, referred to as the ‘Extreme Male Brain Hypothesis (EMB)’ (Baron-Cohen, 2002). According to the EMB hypothesis there are two independent systems in which individuals process and respond to social information: an empathizing system and a systemizing process. The empathizing system, as previously discussed, is the ability to recognize an individual’s mental state and to experience the same emotion as another individual. In regards to social interactions, systemizing involves experiencing a number of interactions and reassessing those experiences piece by piece in order to develop a set of rules that regulate proper social behaviour, similar to a mathematician developing a formula in order to solve a problem. While both sexes employ both strategies, the EMB theory posits that in order to effectively interact in social situations females rely more on the empathising system while males rely more on systemizing processes (Baron-Cohen, 2002). Importantly, social interactions are dynamic processes which change from moment to moment. Therefore, an individual must be able to constantly adapt his or her behavior in order to effectively interact with others. This would be difficult to do when relying on a set of previously established rules for particular instances (i.e., systemization), and the reliance on systemizing may be a reason why males perform more poorly than females on a number of ToM tasks (Baron-Cohen, 2002: 2005).

Baron-Cohen (2002) has suggested that individuals with autism rely solely on systemizing processes, and therefore autism is an “...extreme form of the male brain” (Baron-Cohen, 2002, p. 253). Evidence for this assertion comes from the fact that autism is a predominantly male disorder (Baron-Cohen, 2002). In addition, there are also key structural similarities between the male and autistic brain. As Baron-Cohen (2002) states, males have "... greater numbers and denser packing of neurons... with more intrahemispheric white matter projections from these neurons" (p. 820). The author suggests that this type of anatomical brain structure is better suited for local processing and therefore better suited for systemization, which requires analyzing a complex system piece by piece. On the other hand, empathizing is reliant on global processing in order to combine both cognitive and affective aspects, which are processed by different brain regions. Importantly, Baron-Cohen (2002) has suggested that the atypical white matter connections found in the autistic brain also seem to be better suited for local processing, and is therefore an exaggeration of the male brain.

In order to further elucidate sex differences in ToM reasoning, Russell, Tchanturia, Rahman and Schmidt (2007) conducted a study using a ToM task that assesses the ability to recognize and understand humorous cartoon stories; some of the stories required the capacity to mentalize while others did not. Contrary to the findings previously discussed, Russell and colleagues (2007) found that males scored higher than females on both types of cartoons. Although this result seems to undermine the hypothesis that females are more adept at mentalizing than males, this study highlighted an important aspect of current ToM measures. The authors' state that the sex differences may be due to the processing demands of the task. The ToM measure used in their study required more systemizing abilities rather than empathizing abilities, and therefore a male advantage was observed. If men and women truly differ in terms of the strategies they use to solve ToM tasks then, based on the research by Baron-Cohen (2002), it may be reasonable to assume that females would outperform males on measures assessing affective ToM. This would be consistent with previous studies which have found that females score higher than males on tasks assessing emotional recognition (see McClure, 2000 for a review; Thayer, & Johnsen, 2000). However, as previously stated, there is very little research assessing emotional ToM. The current study will address this issue by exploring whether there are sex differences on affective ToM tasks.

CHAPTER VII: THE CURRENT STUDY

The current study expanded on previous ToM research by creating two non-verbal affective ToM measures. The Affective Visual Theory of Mind Task (AVToM) assesses the perception of *simple* emotions such as happy, sad, or afraid. In this task, participants were shown various emotional scenes and were asked to choose which facial expression of emotion was most appropriate for each scenario. In addition, a second non-verbal ToM task was created in order to assess the more complex, belief-based emotion of embarrassment. As previously discussed, recognizing embarrassment is more difficult than recognizing emotions such as happiness or sadness due to the fact that one must be able to recognize and differentiate between the mental states of the surrounding audience and the individual who has committed the embarrassing act (Hillier & Allison, 2002). Surprisingly, there are very few studies to date that have investigated this complex emotion (Hillier & Allison, 2002). In the Emotional Narrative Task (ENT), participants were shown a series of photographs that depict either an embarrassing or a neutral story and were asked to choose which emotional facial expression best reflected what happened in the narrative.

If recognizing belief-based emotions is more difficult than recognizing simple emotions it may be reasonable to assume that it would take a longer period of time to recognize embarrassing situations compared to neutral situations. Previous research has found that individuals with autism have longer response times when answering questions about the mental states of others compared to control questions (Bowler, 1997; Kaland, Callesen, Moller-Nielsen, Mortension, & Smith, 2008; Kaland, Meller-Neilson, Callesen, Mortensen, Gottlieb, & Smith, 2002), and this effect has also been found in healthy adult participants (Kaland *et al*., 2002). However, there have been no studies to date that have collected response time data with purely affective ToM measures. Therefore, response time data were also collected for the ENT task in order to examine whether healthy adults show increased response latencies for embarrassing versus neutral trials. It was hypothesized that response times would be significantly longer for the embarrassing condition.

In addition to the two non-verbal ToM tasks, participants also completed two well-established ToM measures: the Reading the Mind in the Eyes task (RME) (Baron-Cohen *et al*., 1997) and the Faux Pas Recognition test (FPRT) (Baron-Cohen *et al*., 1999). One of the goals of the current study was to assess whether the AVToM and the ENT tasks correlated with existing ToM measures in healthy adult participants. It is expected that both of the visually based ToM measures, including the AVToM and the ENT, will be significantly and positively correlated with each other and with the FPRT and the RME. Significant correlations between each of the four ToM assessments would support the theory that the non-verbal tasks assess mentalizing abilities similar to that of existing language-based ToM assessments. Such a result would suggest that the AVToM and the ENT could be considered valid assessments of ToM. However, the ToM tasks implemented in this study are slightly different in the sense that the RME is a visually based assessment, while the FPRT is verbally based. Hence, it was also hypothesized that the newly developed non-verbal measures would be more strongly correlated with the RME than with the FPRT.

Another goal of the current experiment was to see whether verbal ability was related to ToM processing. To this end, participants also completed a verbal measure in order to determine whether linguistic ability is correlated with performance on non-verbal ToM tasks, similar to that of verbally based measures. Previous research has found that verbal scores are positively correlated with ToM measures (Cutting & Dunn, 1999) including the FPRT (Baron-Cohen *et al*., 1999). Since both the FPRT and RME tasks are dependent upon linguistic understanding, it is expected that scores on the verbal measures will be positively correlated with scores on both of these tasks. In regards to the new tasks developed for this study, it is difficult to predict whether scores on the AVToM and the ENT measures will correlate with linguistic skill. Previous research has found that linguistic ability is correlated with emotional recognition tasks (Cutting *et al*., 1999; Ruffman *et al*., 2003); however, the measures implemented in those studies have verbal components, while the AVToM and the ENT do not. Therefore, it is reasonable to hypothesize that verbal scores will not be significantly related to scores on the two non-verbal tasks.

The current study will also examine sex differences in ToM scores. Based on previous research that females outperform males on various ToM tasks (Baron-Cohen, 1999: 2001), it was hypothesized that females would display superior scores on the both the FPRT and the RME. Due to the fact that AVToM and the ENT measures are highly dependent on the correct interpretation of emotional scenarios and that females are more accurate than males at emotional recognition (McClure, 2000; Thayer & Johnsen, 2000), it was also expected that females would score higher than males on both of these measures.

In summary, the current study assessed: (1) whether non-verbal affective ToM tasks assess mentalizing abilities similar to that of language-based measures, (2) whether verbal ability is significantly correlated with non-verbal ToM assessments, (3) whether reasoning about embarrassing narratives would require longer processing times compared to reasoning about neutral stories, and (4) whether there are sex differences on the performance on each of the ToM tasks.

Method

Participants

Participants consisted of 80 (46 female and 34 male) Introductory Psychology students recruited from the University of Winnipeg. All students received partial course credit for their participation and had normal or corrected-to-normal vision. Before the study began, participants were asked to read and sign the Informed Consent Form.

Stimulus Sets and Apparatus

<u>Faux Pas Recognition Task (FPRT):</u> Participants completed the Faux Pas Recognition Test developed by Baron-Cohen and colleagues (1999). In this task, the experimenter read 20 different stories to the participants: 10 stories contained a social faux pas while the other ten stories did not. Consistent with previous research, the order of the stories was identical for each participant (Baron-Cohen *et al*., 1999). An example of a story that contains a faux pas is shown below:

> "Sally is a three-year-old girl with a round face and short blonde hair. She was at her Aunt Carol's house. The doorbell rang and her Aunt Carol answered it. It was Mary, a neighbour. "Hi," Aunt Carol said, "Nice of you to stop by." Mary said, "Hello," then looked at Sally and said, "Oh, I don't think I've met this little boy. What's your name?" (p. 416).

After each story is read, participants were asked the following questions:

1. *Did anyone say something they shouldn't have said or something that was awkward??*
2. *Who said something they shouldn't have said or something awkward?*
3. *Why shouldn't he/she have said it or why was it awkward?*
4. *Why do you think he/she said it?*
5. *Did X know that Y...?*
6. *How did (character name) feel?*

If participants answered 'yes' to the first question then they were asked the subsequent questions. If participants answered 'no' to the first question then questions 2-6 were skipped. Regardless of the first response, participants were asked two control questions (questions 7 and 8), in order to ensure that participants understood the premise of the story.

Reading the Mind in the Eyes Task (revised) (RME): Participants completed the revised version of the Reading the Mind in the Eyes Test (Baron-Cohen *et al*., 2001). The revised version of the RME has improved psychometric properties compared to the original version and has been used to assess ToM abilities in both healthy adults and individuals with autism (Baron-Cohen *et al*., 2001). Participants completed a computerized version of the RME. In this task participants viewed 246 mm X 1024 mm (resolution of 246 X 96 pixels) photographs depicting the eye region of the face and were instructed to choose one of the four verbal labels (e.g., fantasizing, alarmed, despondent and impatient) for each expressed emotion. Similar to the original paper version of this test, the order of the trials was identical for all of the participants (Baron-Cohen *et al*., 1997). Participants made their responses by pressing 1-4 on the computer keyboard.

<u>Affective Visual Theory of Mind Task (AVToM):</u> In this task participants viewed five photographs depicting the exact same scenario (see Figure 1). In each of the five pictures, the actor expressed a different emotional facial expression including happy, sad, disgust, afraid and neutral (i.e., no emotion). Participants were asked to choose the picture in which the actor's facial expression matched the displayed situation in the image by pressing 1-5 on the computer keyboard. There were 12 trials for each emotional scenario including happy, sad, afraid, and disgust, and 12 trials for emotionally neutral scenarios. The trial order was randomized. The position of the images was also randomized in order to ensure that the same emotional facial expression was not always presented in the same location. This task was completed on the computer and the size of each image was 90 mm X 67 mm (with a resolution of 350 X 263 pixels). The photos were taken by the experimenter using a Pentax K10D digital SLR camera mounted on a Velbon telescopic tripod.

Figure 1. A depiction of a trial on the affective visual theory of mind task (AVToM). Participants were asked to choose the photo in which the facial expression best matched the scenario by pressing 1-5 on the computer keyboard.

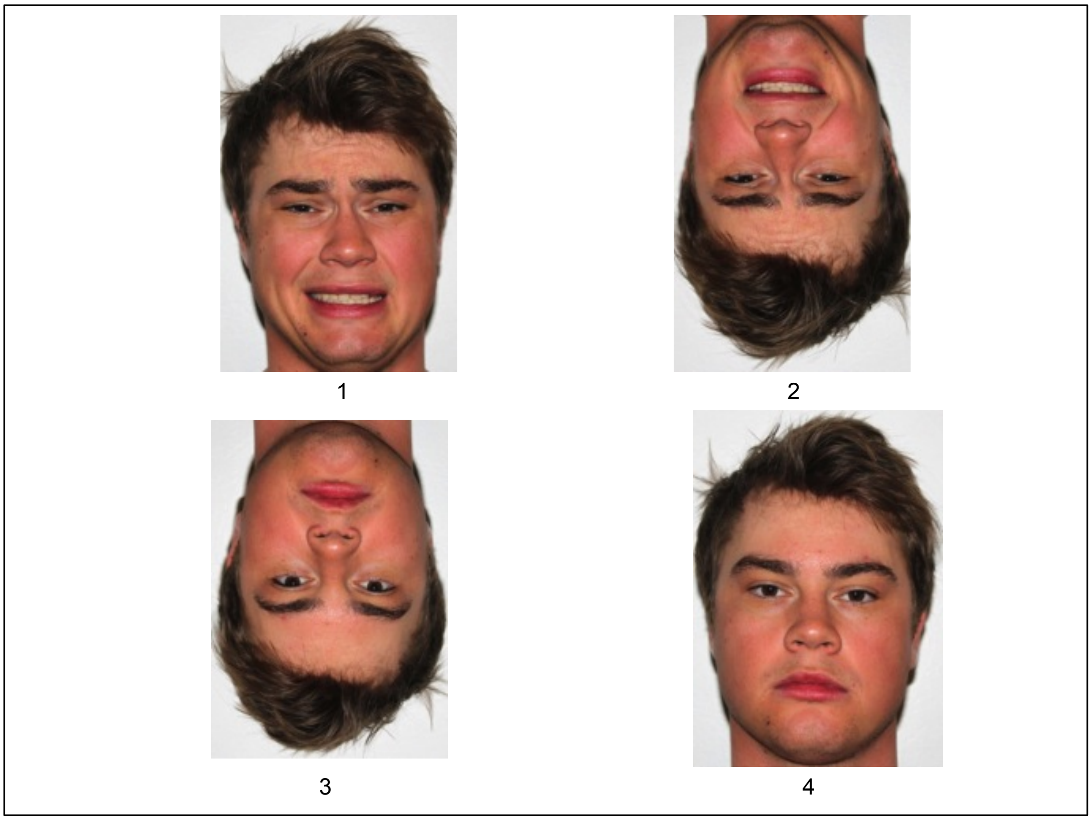
Emotional Narrative Task (ENT): The ENT task was completed on the computer. Each trial for the ENT consisted of two slides. On slide 1, participants viewed five pictures which depicted a short story (see Figure 2, slide 1). An arrow on the computer screen indicated the order of the images. On slide 2, participants were shown four images on the computer screen in which the main actor from the previous story expressed two different emotional facial expressions, including two embarrassed facial expressions and two neutral facial expressions (see Figure 2, slide 2). One of each emotional facial expression (i.e., one embarrassed expression and one neutral expression) was presented upside down. This was done in order to ensure that participants looked at each individual item on the computer screen before making a response. If only two images were presented (i.e., one neutral and one embarrassed facial expression) participants could have employed a “if not A then B” strategy. For example, after an embarrassing narrative was presented participants could have made their responses by only looking at the neutral facial expression and choosing the alternative image because it was “not neutral”. Therefore, including the two upside down images forced participants to look at all of the stimuli and specifically choose *between* neutral and embarrassed facial expressions. The participants were asked to choose the emotional expression that was appropriate for the scenario in the narrative by pressing 1-4 on the computer keyboard.

There were 48 trials on the ENT, including 24 embarrassing and 24 neutral stories. The order of the trials was randomized for each participant. The position of the emotional facial expressions on the test screen (i.e., slide 2) was also randomized so that participants could not predict where the emotional expressions were located before slide 2 appeared. The images were taken by the experimenter with a Pentax K10D digital SLR camera mounted on a Velbon telescopic tripod. The size of each image was 90 mm X 67 mm (with a resolution of 350 X 263 pixels).

Figure 2. A depiction of a trial on the Emotional Narrative Task (ENT). Participants first viewed five pictures depicting a story (slide 1) and were then required to select the facial expression that best suited what happened in the previous narrative (slide 2).

Slide 1

Slide 2



<u>North American Adult Reading Test (NAART):</u> The North American Adult Reading Test (Blair & Spreen, 1989) assesses word-reading ability in adults. This test requires participants to read 61 irregularly spelled words, such as ‘catacomb’, ‘thyme’ or ‘heir’. The NAART is a revised version of the National Adult Reading Test (NART) developed by Nelson (1982) and was specifically developed for use with North American populations. The NAART is an accurate measure of verbal intelligence because each word is irregularly spelled; thus, correct pronunciation is dependent upon the participant’s knowledge of the word and not on phonological guessing (Strauss, Sherman & Spreen, 1998). Additionally, the NAART is a highly reliable measure (Cronbach’s α = .93) and has been shown to accurately assess verbal ability similar to that of the WAIS-R

Vocabulary test (Uttl, 2010). Importantly, it has been shown that neither age nor gender, affect performance on the NAART (Uttl, 2010).

All of the computerized tasks were programmed using E-Prime software (Psychology Software Tools, 2002) and were completed on a Dell Dimension computer with a 15 inch colour monitor and with a resolution of 1152 X 864 pixels. Participants were seated approximately 70 cm away from the computer.

Procedure

Prior to the study participants were asked to read and sign the Informed Consent Form. Once this was accomplished, participants completed the four ToM tasks (i.e., FPRT, ENT, AVToM and the RME) and the verbal measure (i.e., NAART). The order of the tasks was counterbalanced across participants.

Before beginning the FPRT, participants were told that they were going to read 20 stories and would then be asked a series of questions based on the stories. Each story was read out loud, one at a time, by the experimenter and participants were given a paper copy of the vignettes so that they could follow along. In order to decrease the demands on working memory, participants were informed that during the question period they could refer back to the stories at any time. This test contained a total of 20 narratives, 10 which contained a social faux pas and 10 that did not. After each story was read, participants were asked a series of questions, the first of which always centered on whether or not a faux pas was committed. Subsequent questions probed the participants' understanding of the faux pas, and included control questions to ensure that participants understood the premise of the story.

Participants also completed the Reading the Mind in the Eyes (RME) test. This task was completed on the computer and consisted of 36 trials. Each trial consisted of the participants viewing an image of a person's eyes. Participants were asked to choose which of four inner states the eyes were expressing (e.g., concerned). Participants made their responses by pressing 1-4 on the computer keyboard.

In the AVToM task, participants viewed five pictures on the computer screen, each picture depicting the exact same scenario. However, the actor in each of the five photographs expressed a different emotion including sad, happy, disgust, afraid, and neutral (i.e., no emotion). Participants were instructed to choose the picture in which the facial expression matched the situation displayed in the images. Subjects made their responses by pressing 1-5 on the computer keyboard, each number corresponding to one of the five pictures. There were a total of 60 trials for this task.

Participants also completed 48 trials of the Emotional Narrative Task (ENT). In this task, participants first viewed five pictures which depicted a short story. Once participants understood the premise of the story they were told to press the spacebar on the computer keyboard in order to view the next slide. Participants were then shown four photographs of the main actor expressing two different emotional facial expressions; two pictures of the embarrassing facial expression and two images of the neutral facial expression. Two of the images (one embarrassing and one neutral facial expression) were presented upside down. Participants were asked to choose the emotional expression that best suited the premise of the narrative by pressing 1-4 on the computer keyboard. For this task, and only for slide 2, participants were instructed to respond as quickly and as accurately as possible.

In order to assess verbal intellect, participants completed the North American Adult Reading Test (NAART). In this test participants read words that are spelled in ways that violate correct English pronunciation. Subjects were given a sheet which listed all 61 words and were instructed to read each word out loud, one at a time, and to move on to the next word only when the experimenter says "next". If participants were unfamiliar with some of the words, they were encouraged to make their best guess. Scores were based on the accurate pronunciation of the items.

Analysis

Faux Pas Recognition Test (FPRT)

Scores for the faux pas recognition test were divided into four sections: 1) Questions 1-6 on the Faux Pas Stories (FPFP), 2) Control questions (#7 and #8) on the Faux Pas stories (CCFP), 3) Questions 1-6 on the Control Stories (FPCC) and 4) Control Questions (#7 and #8) on the Control Stories (CCCC). For the stories that contained a faux pas, if participants answered questions 1-6 correctly, then they were awarded one point per question yielding a maximum possible score of 60 points. If participants answered 'no' to the first question, and therefore failed to detect the faux pas, then they received 0 points for questions 1-6. Each correctly answered control question (# 7 and #8), was given 1 point, yielding a total possible score of 20 points.

For the control stories that did not contain a faux pas, if participants correctly answered 'no' to the first question and therefore accurately determined that no one said anything awkward, questions 2-6 were skipped and the experimenter proceeded to ask the control questions (#7 and #8). The participant was given 2 points each time he/she correctly stated that no faux pas was committed. The maximum possible score for this section was 20 points. Each correctly answered control question on the control stories was awarded 1 point. The maximum possible score for this section was 21 (one story contained 3 control questions).

If a participant answered a control question incorrectly on either the faux pas or the non-faux pas vignettes, then the scores for that story were removed. The participant was then given a corrected total out of 54 or 48 points depending on how many control questions were answered incorrectly. In order to compare performance across all of the ToM tasks, scores were then converted into percentages.

The Reading the Mind in the Eyes Task (RME)

Each correct answer on the RME was allocated 1 point, yielding a total possible score of 36. A percent correct was calculated for each participant.

Affective Visual Theory of Mind Task (AVToM)

There were a total of 60 trials in this task, divided into 12 trials per emotion type (i.e., happy, sad, disgust, afraid, and neutral). Participants were awarded 1 point for each correct response, resulting in a maximum possible score of 60. Individual scores were also calculated for each emotion type, producing a score out of 12 for happy, sad, disgust, afraid and neutral trials. Scores were converted into percentages.

Emotional Narrative Task (ENT)

Accuracy

The ENT task consisted of 48 trials, including 24 embarrassing stories and 24 neutral stories. Participants were given one point for choosing the correct emotional facial expression, yielding a maximum possible score of 48. Separate scores were also calculated for embarrassing and neutral trials, producing a score out of 24 for each emotion type. Scores were then converted into percentages.

Response Time

In addition to accuracy, response times (RTs) were recorded for the ENT task. Upon observation of the data, it was found that some of the RTs were either exceedingly long or exceptionally short. These 'outlier' RTs may be due to circumstances such as the participant's lack of attention on that particular trial or rapid guessing, and not necessarily related to ToM processing. Therefore, an outlier analysis was performed. First, incorrect trials were eliminated from subsequent analysis. Next, means and standard deviations were calculated for each participant. Trials in which the RT was longer than 3 standard deviations above the mean (for that participant) were discarded from further analysis. In addition, RTs that were shorter than 200 ms were also deleted due to the fact that this time period is too short to be involved in mentalizing and may be due to the participant rushing through the task (Luce, 1986; Whelan, 2008). After the outlier analysis was performed, average RTs were calculated for the entire ENT task, as well as for embarrassing and neutral trials. A paired sample t-test was used in order to determine whether there were differences in RTs between neutral and embarrassing trials. In addition, one-way between-subjects ANOVAs were used in order to determine whether there were sex differences for overall RTs on the ENT task, as well as for RTs on embarrassing and neutral trials.

Performance on the ToM tasks

Mean accuracy scores for each of the ToM tasks were submitted to separate paired sample t-tests (with correction for multiple comparisons) in order to determine whether there were performance differences across the ToM tasks. This analysis helped reveal whether participants performed better on one ToM task compared to another. Similar analyses were conducted in order to determine whether there were performance differences on each emotion type for the AVToM task and the ENT task (e.g., higher accuracy for ‘happy’ trials versus ‘afraid’ on the AVToM).

Sex Differences

In order to examine whether there are sex differences in performance on the ToM tasks (e.g., female scores versus males scores on the FPRT) and the NAART, mean accuracy scores for males and females were used in five separate, one-way between-subjects ANOVAs. Due to the fact that the AVToM task includes five different emotions, and the ENT includes two different emotions, sex differences on emotion type were also examined via separate between-subjects ANOVAs (e.g., females versus males for ‘sad’ trials in the AVToM).

Correlations

One of the goals of this experiment was to see whether the two novel visual ToM measures assess mentalizing abilities similar to that of verbally based measures in healthy adults. To this end, correlation analyses were conducted in order to determine whether the four ToM measures were related to one another. For the AVToM task, data were divided according to emotion type in order to assess whether detection of sad, happy, afraid, disgust, and neutral scenarios correlated with both the RME and FPRT scores. Similar analyses were conducted for the ENT task: embarrassing and neutral scenarios were separated in order to determine whether scores on those specific trials correlated with existing ToM measures.

In order to assess the relationship between language ability and performance on the ToM measures, separate correlation analyses were conducted between each of the ToM measures and the NAART. In addition, partial correlation analyses were used in order to determine whether the ToM assessments are significantly related to one another when controlling for verbal ability (i.e., scores on the NAART).

Results

All statistical analysis was completed using the Statistical Package for the Social Sciences (SPSS), Version 14.0 (SPSS Inc., Chicago, Illinois).

Comparison of Performance on the Different ToM Tasks

Means accuracy scores and standard deviations for each of the ToM tasks are listed in Table 1 and in Figure 3. Paired t-tests were used in order to assess whether there were significant performance differences between each of the ToM tasks. In order to control for multiple comparisons, a Bonferroni correction was implemented. The familywise error rate was set at $\alpha = 0.05$; this value was divided by the number of comparisons. The error rate per comparison for this analysis was set at $\alpha = 0.008$ (0.05/6). Therefore, comparisons that resulted in a p-value less than 0.008 were considered significant.

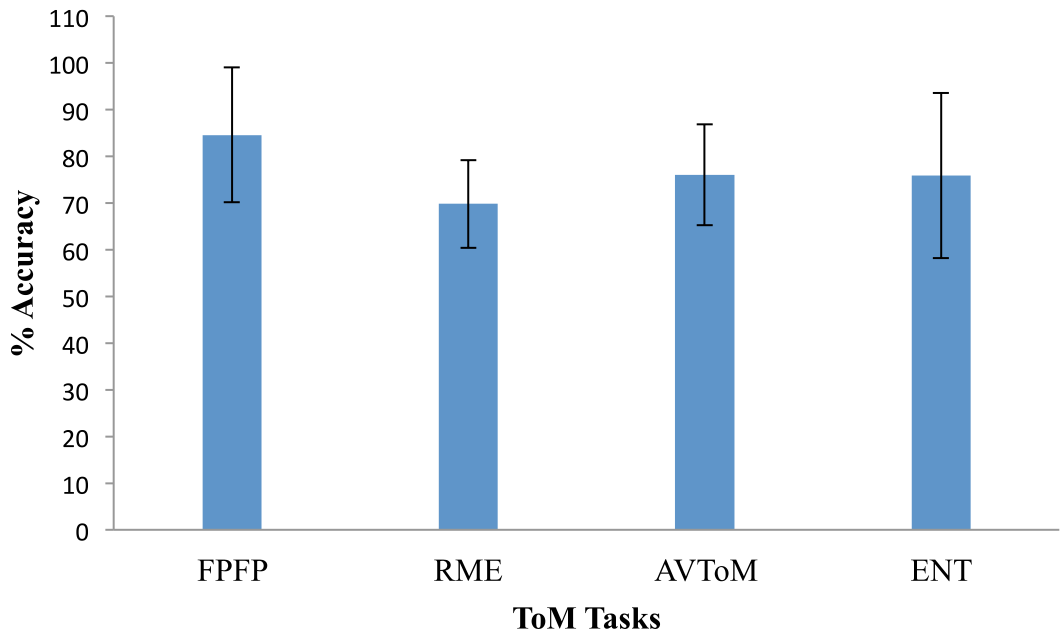
Upon examination of performance across tasks it was found that scores on the faux pas questions on the FPRT ($M = 84.59$) were significantly higher than scores on the RME task ($M = 69.79$), $t(79) = 8.92$ $p < 0.008$, the AVToM task ($M = 76.08$), $t(79) = 4.805$ $p < 0.008$, and the ENT task ($M = 75.88$), $t(79) = 3.56$ $p < 0.008$. In addition, scores on the AVToM ($M = 76.08$) were significantly higher than scores on the RME ($M = 69.79$), $t(79) = 4.15$ $p < 0.008$ and scores on the ENT ($M = 75.88$) task were higher than scores on the RME (*M* = 69.79), *t*(79) = 2.71 *p* = 0.008. However, no significant differences were found between performance on the AVToM task and the ENT task. This analysis revealed a general trend in which participants had the highest mean accuracy percentage on the faux pas questions (i.e., FPRT), followed by mean accuracy scores on the AVToM and the ENT. Participants scored the lowest on the RME task.

Table 1.
Mean percent accuracy and standard deviations for the Theory of Mind (ToM) tasks

ToM Tasks	Mean	SD
FPRT		
FPFP	84.59	14.42
CCFP	99.13	2.22
FPCC	96.07	6.17
CCCC	99.11	2.02
RME	69.79	9.43
AVToM	76.08	10.83
ENT	75.88	17.70

FPRT = Faux pas Recognition Test; FPFP = Faux Pas Questions on the Faux Pas Recognition Test; CCFP = Control Questions of the Faux Pas Stories; FPCC = Faux Pas Questions on the Control Stories; CCCC = Control Questions on the Control Stories; RME = Reading the Mind in the Eyes Test; AVToM = Affective Visual Theory of Mind Test; ENT = Emotional Narrative Task.

Figure 3. Percent accuracy (+/- *SD*) for the Faux Pas Recognition Test (FPRT), Reading the Mind in the Eyes Test (RME), Affective Visual Theory of Mind Task (AVToM) and the Emotional Narrative Task (ENT).



AVToM Analyses

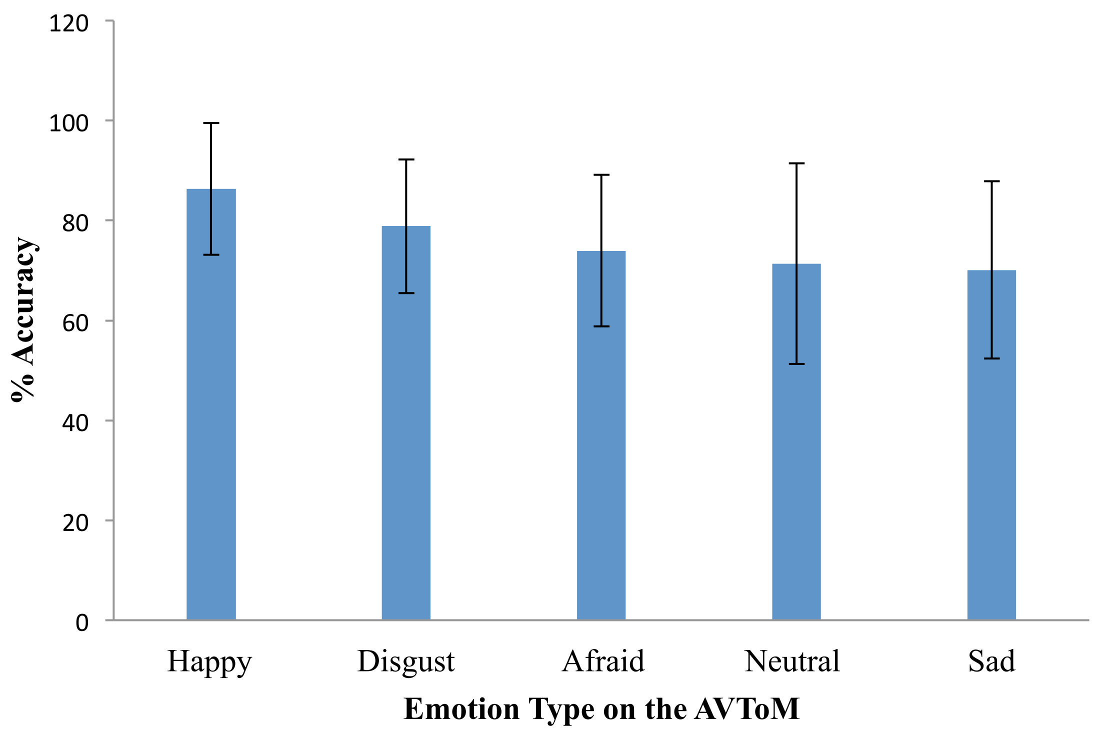
Further analyses were conducted in order to see whether there were performance differences between emotion types on the AVToM task. Mean accuracy scores revealed that participants had the highest percent accuracy on 'happy' trials, followed by disgust, afraid, neutral, and sad (see Table 2, and Figure 4). Similar to the previous analyses, Bonferroni corrections were performed to control for multiple comparisons. The error rate per comparison for this analysis was set at $\alpha = 0.005$ (0.05/10). Significant differences were found for the following comparisons: happy versus neutral, $t(79) = 6.31$ $p < 0.005$, happy versus sad, $t(79) = 7.51$ $p < 0.005$, happy versus disgust, $t(79) = 4.33$ $p < 0.005$, happy versus afraid, $t(79) = 7.02$ $p < 0.005$, and sad versus disgust, $t(79) = 4.55$ $p < 0.005$.

Table 2.
Percent accuracy per emotion type on the Affective Visual Theory of Mind Task (AVToM)

AVToM Emotions	Mean	SD
Happy	86.35	13.21
Sad	70.10	17.72
Disgust	78.85	13.38
Afraid	73.96	15.14
Neutral	71.35	20.06

AVToM = Affective Visual Theory of Mind Task.

Figure 4. Percent accuracy per emotion type (+/- *SD*) on the Affective Visual Theory of Mind (AVToM) task.



ENT

Analyses were conducted to examine whether there were performance differences between emotion types on the ENT task. No significant differences were found in regards to mean accuracy for embarrassing (*M* = 76.25, *SD* = 18.77) versus neutral trials (*M* =75.57, *SD* = 18.56): all *F*-values < 1, $p > 0.05$.

Prior to the calculation of average RTs for the ENT task, an outlier analysis was performed in which 25.39 percent of the total number of trials were deleted from subsequent analyses. Average RTs for embarrassing and neutral trials of the ENT task (see Table 3) were compared using a paired-samples t-test. Although the average RTs for embarrassing trials (*M* = 2097.64, *SD* = 712.74) were slightly longer than the average RTs for neutral trials (*M* = 2049.52, *SD* = 738.04), this difference was not significant, $t(79) = 1.33$ $p > 0.05$.

Table 3.
Average response times (ms) for the Emotional Narrative task (ENT), including average response times for embarrassing and neutral trials

	Mean	SD
Total ENT	2075.07	712.74
Embarrassing Trials	2097.64	719.26
Neutral Trials	2049.52	738.04

ENT = Emotional Narrative Task

Sex Differences

Mean accuracy scores and standard deviations for females and males on the ToM tasks and the NAART are listed in Table 4. One-way, between-subjects ANOVAs were used in order to assess sex differences on performance on each of the ToM tasks.

However, Levene's test for homogeneity of variance revealed that two comparisons violated the homoscedasticity assumption, including performance on the RME task, *Levene's* $F(1,78) = 6.85$, $p < 0.05$ and scores on the FPCC component of the FPRT, *Levene's* $F(1,78) = 15.53$, $p < 0.01$. In addition, Levene's F-test also approached significance for two other comparisons including performance on the FPRT, *Levene's* $F(1,78) = 3.47$, $p = 0.06$, and scores on the ENT, *Levene's* $F(1,78) = 3.90$, $p = 0.05$. Therefore Welch's F-tests were used for those specific comparisons. One-way, between subjects ANOVAs, and Welch's F-tests, revealed that there were no significant performance differences between males and females on any of the ToM tasks (all $p > 0.05$) (see Table 4). Therefore, in contrast to previous research, which has found that females tend to outperform males on different ToM measures (Baron-Cohen *et al.,* 1997, 2001), the current study found that males and females were similar in their mentalizing abilities. In addition, no significant performance differences were found on the NAART. Therefore, males and females were similar in regards to verbal skill.

Table 4.
Descriptive statistics and F-values for comparisons between males and females on the Theory of Mind (ToM) tasks and the North American Adult Reading Test (NAART).

	Gender		Statistics		
	Females	Males			
Tasks	Mean (*SD*)	Mean (*SD*)	*F* (1,78)[a]	Welch's *F*(*df*)	*P*
FPRT					
FPFP	50.24 (10.20)	50.94 (5.9)	0.37	-	0.54
CCFP	19.83 (0.44)	19.82 (0.46)	0.001	-	0.98
FPCC	19.43 (0.91)	18.94 (1.50)	-	2.84(1,50.73)	0.09
CCCC	20.78 (0.47)	20.85 (0.36)	0.54	-	0.47
RME	25.15 (3.77)	25.09 (2.87)	-	0.01(1,77.90)	0.93
AVToM	46.47 (7.29)	44.53 (5.14)	-	1.97(1,77.86)	0.17
Happy	10.23 (1.83)	10.53 (1.19)	0.65	-	0.42
Sad	8.78 (2.24)	7.90 (1.88)	3.38	-	0.07
Afraid	9.26 (1.90)	8.29 (1.66)	5.58*	-	0.02
Disgust	9.65 (1.52)	9.21 (1.70)	1.98	-	0.16
Neutral	8.54 (2.46)	8.59 (2.38)	0.001	-	0.98
ENT	37.13 (7.41)	35.47 (9.8)	-	0.68(1,58.94)	0.41
Emb	18.61 (4.05)	17.88 (5.09)	0.22	-	0.64
Neutral	18.50 (4.05)	17.53 (4.91)	0.04	-	0.84
NAART	28.67 (8.03)	30.21 (8.50)	0.68	-	0.41

FPRT = Faux pas Recognition Test; FPFP = Faux Pas Questions on the Faux Pas Recognition Test; CCFP = Control Questions of the Faux Pas Stories; FPCC = Faux Pas Questions on the Control Stories; CCCC = Control Questions on the Control Stories; RME = Reading the Mind in the Eyes Test; AVToM = Affective Visual Theory of Mind Test; ENT = Emotional Narrative Task; NAART = North American Adult Reading Test.
*$p < 0.05$
**$p < 0.01$
[a] One-factor ANOVA

Examination of performance differences on emotion type (for the ENT and AVToM tasks) revealed that females were more accurate than males at identifying fearful scenarios on the AVToM task, $F\ (1, 78) = 5.58$, $p < 0.05$. However, no other comparisons were significant (all $p > 0.05$).

Average RTs for males and females on the ENT task are listed in Table 5. Mean RTs for females were longer than mean RTs for males on total ENT trials, embarrassing trials and neutral trials. However, separate between-subjects ANOVAs revealed that these differences were not significant (all F-values < 1, $p > 0.05$). Therefore, both males and females had similar response latencies when identifying embarrassing and neutral scenarios.

Due to the fact that no significant sex differences were found on overall performance between the ToM measures or on the NAART, I collapsed across sex for subsequent analyses.

Table 5.
Average response times (ms) for females and males on the Emotional Narrative Task (ENT).

	Gender			
	Females		Males	
	Mean	SD	Mean	SD
Total ENT	2092.78	634.61	2051.10	815.87
Embarrassing Trials	2124.86	655.19	2060.82	846.30
Neutral Trials	2056.98	96.97	2039.42	805.28

ENT = Emotional Narrative Task.

Correlations Between the ToM Tasks

Correlations between the ToM measures are listed in Table 6. Performance on the faux pas questions of the FPRT was positively correlated with the RME task, $r = 0.283$, $p < 0.05$. This result is consistent with previous research, which has reported positive correlations among these two measures (de Achaval *et al*., 2010; Torralva *et al.,* 2007). Therefore, it is reasonable to conclude that both measures are assessing similar aspects of ToM. No significant correlations were found between the control questions (on either the faux pas stories or the non-faux pas stories) or control stories and the RME task. This null result may be due to the fact that the control components of the FPRT are not assessing mentalizing abilities but are instead testing story comprehension. In addition, the RME task does not contain any control trials which do not involve ToM processing. Therefore, the lack of a relationship between the RME and control trials on the FPRT could lend support to the notion that mentalizing abilities are dissociable from other cognitive processes such as narrative comprehension.

A positive correlation was found between the faux pas stories on the FPRT and total scores on the AVToM, $r = 0.24$, $p <0.05$ (see Table 6). This result is consistent with the hypothesis that the AVToM and the FPRT assess similar processes, presumably ToM. The control questions on both the faux pas stories (CCFP) and non-faux pas stories (CCCC), and scores on the control stories (FPCC) did not correlate significantly with the AVToM. Upon examination of the relationship between specific emotion types and the FPRT, it was found that neutral trials on the AVToM were positively correlated with faux pas questions on the FPRT, $r = 0.24$, $p < 0.05$ (See Table 7). A possible explanation for this counterintuitive result is that the neutral condition in the AVToM task had a larger standard deviation (*SD* = 20.06) compared to happy (*SD* = 13.21), sad (*SD* = 17.72), disgust (*SD* =13.38), and afraid (*SD* = 15.14). These large individual differences may have produced a spurious correlation between neutral trials and the FPRT.

One other significant relationship was found between the ToM tasks: a positive correlation was observed between overall scores on the AVToM and total scores on the ENT, $r = 0.23$, $p < 0.05$ (see Table 6). In order to elucidate this relationship, the correlations between overall performance on one task and specific emotion types on the other task were examined. The association between the AVToM and the ENT was primarily driven by the positive relationship between happy trials, $r = 0.26$, $p < 0.05$, and afraid trials on the AVToM, $r = 0.247$, $p < 0.05$, with total scores on the ENT. Neutral trials on the ENT task was also correlated with overall scores on the AVToM, $r = 0.236$, $p < 0.05$. Further analyses were completed in order to see which particular emotion types were related to one another on the two tasks. The results of this analysis revealed that happy trials on the AVToM was correlated with embarrassing trials on the ENT, $r = 0.25$, $p < 0.05$, and neutral trials on the ENT, $r = 0.247$, $p < 0.05$. Finally, afraid trials on the AVToM task were related to neutral trials on the ENT, $r = 0.273$, $p < 0.05$.

Contrary to previous hypotheses, not all of the ToM measures were related to one another. No significant correlations were found between the faux pas stories on the FPRT and the ENT, between the AVToM and RME, and between the ENT and the RME.

Table 6.
Correlations between the Theory of Mind (ToM) measures.

	AVToM	RME	ENT
FPRT			
FPFP	0.240*	0.283*	0.115
CCFP	0.137	0.099	0.107
FPCC	0.064	0.101	0.083
CCCC	0.183	0.148	-0.009
AVToM	-	0.107	0.230*
RME	-	-	-0.005
ENT	-	-	-

FPRT = Faux pas Recognition Test; FPFP = Faux Pas Questions on the Faux Pas Recognition Test; CCFP = Control Questions of the Faux Pas Stories; FPCC = Faux Pas Questions on the Control Stories; CCCC = Control Questions on the Control Stories; RME = Reading the Mind in the Eyes Test; AVToM = Affective Visual Theory of Mind Test; ENT = Emotional Narrative Task.
* $p < .05$

Table 7.
Correlations between faux pas questions on the Faux Pas Recognition Test (FPRT) and the Affective Visual Theory of Mind task (AVToM).

	AVToM				
	Happy	Sad	Afraid	Disgust	Neutral
FPRT					
FPFP	0.07	0.20	0.16	0.11	0.24*

FPRT = Faux Pas Recognition Test; FPFP = Faux Pas Questions on the Faux Pas Recognition Test.
* $p < .05$

Correlation of ToM tasks with Verbal Ability (NAART)

The correlations of the ToM assessments with scores on the NAART revealed that two of the ToM tasks were related to verbal ability (see Table 8). A positive correlation was found between scores on the NAART and scores on the RME, $r = 0.27$, $p < 0.05$.

This result was expected due to the fact that the RME requires participants to match visual stimuli with verbal labels. Surprisingly, scores on the NAART were also positively related with performance on the AVToM task, $r = 0.26$, $p < 0.05$. NAART scores were most strongly related to afraid trials, $r = 0.29$ $p < 0.01$, and neutral trials, $r = 0.26$ $p < 0.05$ (see Table 9). Contrary to previous predictions, no significant relationship was found between the NAART and either the faux pas or the control questions on the FPRT (see Table 10). Additionally, verbal ability was not shown to be correlated with the ENT task.

Table 8.
Correlations between the Affective Visual Theory of Mind Task (AVToM), Reading the Mind in the Eyes Task (RME, Emotional Narrative Task (ENT) and scores on the North American Adult Reading Test (NAART).

		ToM Tasks	
	AVToM	RME	ENT
NAART	0.26*	0.27*	0.006

RME = Reading the Mind in the Eyes Test; AVToM = Affective Visual Theory of Mind Test; ENT = Emotional Narrative Task; NAART = North Amercian Adult Reading Test.
* $p < 0.05$

Table 9.
Correlations between emotion type on the Affective Visual Theory of Mind Task (AVToM) and scores on the North American Adult Reading Test (NAART).

	AVToM				
	Happy	Sad	Disgust	Afraid	Neutral
NAART	-0.002	0.15	0.14	0.29**	0.26*

AVToM = Affective Visual Theory of Mind Task; NAART = North American Adult Reading Test.
* $p < 0.05$
** $p < 0.01$

Table 10.
Correlations between the North American Adult Reading Test (NAART) and the Faux Pas Recognition Test (FPRT)

	FPRT			
	FPFP	CCFP	FPCC	CCCC
NAART	0.10	0.21	0.06	0.00

FPRT = Faux pas Recognition Test; FPFP = Faux Pas Questions on the Faux Pas Recognition Test; CCFP = Control Questions of the Faux Pas Stories; FPCC = Faux Pas Questions on the Control Stories; CCCC = Control Questions on the Control Stories; NAART = North American Adult Reading Test.
* $p < .05$

Partial Correlations

Previous analyses indicated that verbal ability, as assessed by the NAART, was correlated with two of the ToM measures. It is important to determine whether verbal ability is mediating the relationships among the ToM tasks. Partial correlation analyses revealed that when controlling for performance on the NAART, the relationship between scores on the faux pas stories of the FPRT and the RME remained significant, $r = 0.27$ $p < 0.05$ (see Table 11). Therefore, both the FPRT and RME are assessing a similar aspect of ToM and are not simply related because of the linguistic demands in both tasks. When controlling for verbal skill, the correlation between overall scores on the AVToM and faux pas stories on the FPRT also remained significant, $r = 0.22$ $p < 0.05$. The relationship between total scores on the AVToM and the ENT remained unchanged after controlling for scores on the NAART, $r = 0.24$ $p < 0.05$. Although verbal skill may be an important aspect of ToM reasoning, these analyses revealed that these measures are assessing processes other than word-reading ability, presumably ToM. Finally, partial correlation analyses did not change the relationships among the other ToM tasks (i.e., the correlations remained non-significant).

Table 11.
Partial correlations between the Theory of Mind (ToM) measures, controlling for scores on the North American Adult Reading Test (NAART).

	AVToM	RME	ENT
FPRT			
FPFP	0.22*	0.27*	0.09
AVToM	-	0.04	0.24*
RME	-	-	-0.01

FPRT = Faux pas Recognition Test; FPFP = Faux Pas Questions on the Faux Pas Recognition Test; RME = Reading the Mind in the Eyes Test; AVToM = Affective Visual Theory of Mind Test; ENT = Emotional Narrative Task.
* $p < .005$

Comparison with Normative Data

Previous analyses revealed that the correlations between the various ToM measures were not as strong as originally predicted. One aspect that could have affected the results of this study was if the sample used in the current experiment was not representative of the general population. Therefore, the mean scores reported in this study were compared to normative data for the RME task and the NAART. Surprisingly, to date, normative data for the FPRT for healthy adults has not been reported. In addition, experimenters that have used the FPRT in their study have differed in terms of how they score the FPRT (Tarralva *et al*., 2007; Stone *et al*., 1998), making comparisons across studies exceptionally difficult.

Normative data for the NAART has been reported by Spreen and Strauss (1998). Independent samples t-test revealed that there was a significant difference in performance on the NAART between the sample in the current study ($M = 29.22$, $SD = 8.22$, $N = 80$) and established norms for this age group ($M = 38.46$, $SD = 9.29$, $N = 52$), $t(1, 130) = 5.92$ $p < 0.01$. Therefore, the verbal intelligence of participants in the current study was well below reported norms, a factor that likely weakened the associations between the verbal measure and the assessments of ToM.

Data for the RME task in this study was compared to the data reported by Baron-Cohen and colleagues (2001). Examination of group differences using an independent samples t-test revealed that there was a significant difference between mean scores on the RME for this study ($M = 25.13$, $SD = 3.40$, $N = 80$) and mean scores reported by Baron-Cohen and colleagues (2001) ($M = 26.2$, $SD = 3.6$, $N = 122$), $t(1,200) = 2.11$ $p < 0.05$. However, the difference between the means of the two groups was quite small. This significant result may be due to the fact that the sample sizes are quite large and increasing sample sizes can increase the chance of finding a significant difference between groups even when the effect is small (Cohen, 1994).

Chapter VIII: Discussion

Current ToM measures that are used to assess mentalizing abilities in children and adults are highly dependent on verbal skill. This is a concern because existing measures may not be purely assessing ToM understanding but linguistic ability as well. In addition, the measures used to assess ToM typically focus on cognitive aspects of mentalizing and ignore affective understanding. The current study expanded on previous ToM research by creating two non-verbal, affective ToM tasks–one assessing the perception of simple emotions such as sad or happy (i.e., the AVToM) and the other assessing the complex emotion of embarrassment (i.e., the ENT). The first goal of the current study was to determine whether non-verbal, purely affective ToM measures correlate with established ToM assessments. Based on the notion that emotional recognition is a vital component of ToM (Shamay-Tsoory *et al*., 2005), it was predicted that the affective ToM tasks developed for this study would be positively correlated with both the RME and the FPRT. The second goal of the present study was to determine whether linguistic skill is related to both verbal and non-verbal ToM tasks. Since performance on the FPRT is dependent upon the ability to understand a complex narrative and performance on the RME is dependent upon the ability to match verbal labels with images of the eyes, it was predicted that linguistic skill would be more strongly related with both of these tasks compared to the AVToM and the ENT. The third goal of the current study was to determine how long it would take for healthy individuals to recognize the complicated, belief-based emotion of embarrassment. In order to understand embarrassment, an individual must first be able to recognize the perspectives of both the person who has committed an embarrassing act and the surrounding audience (Hillier *et al.,* 2002). Based on this notion, it was predicted that recognizing embarrassing narratives would require longer periods of time than recognizing neutral stories. The final goal of the present study was to see whether there are sex differences on the performance of each of the ToM tasks. It was anticipated that females would score higher than males on all of the various ToM assessments.

The findings of the present study supported some, but not all, of the hypotheses described above. The results showed that the two non-verbal measures created for this study assess mentalizing abilities in a manner similar to that of established measures (i.e., RME and FPRT). Specifically, positive correlations were found between the FPRT and RME, the AVToM and FPRT, and the AVToM and ENT. In addition, it was found that linguistic skill (i.e., scores on the NAART) was not mediating the relationships among the ToM tasks. Therefore the ToM measures used in the current study assess a common process independent of verbal skill, presumably ToM. Contrary to prior predictions, no significant differences were found in responses latencies when comparing embarrassing versus neutral trials on the ENT task. In addition, male and females did not differ in performance on the ToM assessments.

Performance on the Different ToM tasks

There were a number of significant performance differences between each of the ToM tasks, suggesting that some of the assessments were more difficult to complete than others. While performance on the FPRT was superior to that on every other measure, scores on the AVToM and the ENT were nearly equivalent. There are a couple of different explanations as to why this occurred. Prior to the development of the FPRT, few ToM measures assessed mentalizing abilities in individuals older than six years of age.

The FPRT was created in order to examine ToM reasoning in adolescence between the ages of 9 and 11, and to assess the ability to detect a faux pas in individuals with autism (Baron-Cohen *et al*., 1999). The participants used in the current study were healthy university students and therefore 17 years of age or older. If ToM continues to develop and evolve well into the adult years, then the mentalizing abilities of the sample used in the present study should be more sophisticated than that of a 9- or 11-year-old. Therefore, it is possible that the participants in this study found the FPRT easy to complete. Importantly, the AVToM and the ENT are both visually based assessments in which participants had to analyze complex emotional scenes and correctly identify a variety of different affective states. This increased complexity may explain why performance was similar across the AVToM and ENT tasks and why these measures were more difficult compared to the FPRT. Differences in task presentation may also be a reason why participants found the RME particularly challenging.

Participants performed considerably worse on the RME task than on the other tests of ToM. One possible explanation for this result is that the RME task requires participants to make mental state judgements based on very limited information–a picture of the eye region of the face. This is vastly different from the AVToM and the ENT tasks in which participants are able to use contextual cues when making decisions about the affective state of another individual. Therefore, in the ENT and AVToM measures, participants are given more information to make their mental state decisions and this may be the reason why performance on these two tasks was superior to performance on the RME. Another possible explanation for low scores on the RME is that the sample used in the current study was not representative of the general population. Indeed, there was a statistically significant difference between the RME scores from the sample in the current study (M = 25.13) and the RME scores reported by Baron-Cohen and colleagues (2001) (M = 26.2). However, the actual difference between group means was very small suggesting that other factors likely influenced this poor performance. One of these factors may be related to verbal skill. In order to perform well on the RME task participants must have an extensive vocabulary and understand words such as "imploring" or "aghast" (Baron-Cohen *et al*., 2001, pg. 248). The low performance on the NAART suggests that the participants used in this study did not have an extensive vocabulary and therefore may not have understood the words presented to them on the RME measure. This idea is supported by the finding that scores on the NAART were significantly correlated with scores on the RME, above all other ToM measures.

The non-verbal tasks developed for the current study assess the perception of various emotional states, and while there were significant performance differences between the ToM tasks there were also differences between scores on different emotion types. In the AVToM task, superior performance was observed on 'happy' scenarios, followed by disgust, afraid, neutral, and sad. The finding that participants were most accurate at recognizing 'happy' scenarios in the AVToM task coincides with the finding that 'happy' is the most easily identified emotional facial expression (Montagne, Kessels, Frigerio, de Haan, & Perrett, 2005; Rapcsak, Galper, Comer, Reminger, Neilsen, Kaszniak, *et al*., 2000; Smith, Montagne, Perrett, Gill, & Gallagher, 2010). For example, Rapcsak and colleagues (2000) found that while participants had the highest accuracy rates for happy facial expressions, recognizing emotions such as sadness, disgust, and fear was more difficult. Similarly, the results of the present study found that emotional scenes depicting sadness, disgust, and fear were more difficult to identify. This suggests that participants were more accurate at using contextual information to infer an individual's happiness compared to sadness, disgust, fear, or no emotion. Therefore the results of the current study expanded on previous research by finding that the 'happiness' advantage is not limited to the identification of emotional facial expressions but is also found for understanding emotion scenarios.

The results of the present study found that there were significant performance differences between the ToM assessments. Based on this finding it was important to explore the relationships between the ToM measures in order to determine whether each of the tasks are related and therefore, assess similar components of ToM.

Correlations Between the ToM Tasks

A goal of the current study was to determine whether the ToM tasks used in the current study were correlated with one another. Consistent with previous research (de Achaval *et al*., 2010; Torralva *et al*., 2007) performance on the faux pas questions on the FPRT was positively related to the RME task. Although significant, the correlation between these two measures was still relatively low ($r = 0.283$); this may be due to differences in task presentation. The FPRT is dependent on both receptive and expressive verbal skill, while the RME is a perceptually based assessment (Kaland *et al*., 2008). However, the fact that some relationship exists suggests that both of these tasks are measuring common aspects of ToM.

Based on the fact that the AVToM and RME tasks are visual assessments of ToM, it was hypothesized that scores on the AVToM would be related to the RME task, as opposed to the FPRT. Contrary to this hypothesis, performance on the AVToM measure was most strongly related to faux pas questions on the FPRT. This result may be due to the fact that both measures contain contextual information while the RME does not. For example, performance on the FPRT is based on the ability to break down elements of complex social situations in order to determine whether anyone said something awkward or out of place. Similarly, performance on the AVToM is based upon deconstructing images in order to use particular contextual elements to infer which emotional facial expression is most appropriate. The RME task can be differentiated from the AVToM and the FPRT because participants infer mental states based on pictures of the eye region of the face, and therefore no contextual information is provided. However, similar to the previous discussion the correlation between the FPRT and the AVToM was low (r = 0.24), possibly reflecting the fact that the AVToM has no (overtly) verbal components. Nonetheless, the correlation between the FPRT and AVToM supports the notion that the AVToM task assesses mentalizing abilities.

The importance of contextual information is also demonstrated by the correlation of the AVToM and ENT tasks. In addition to the use of context, these tasks share two other characteristics. First, neither task is overly linguistic in nature. Second, both appear to assess some (likely overlapping) component of ToM. However, the correlation between the AVToM and ENT tasks was weak (r = 0.23). One explanation for this small effect is that the two tasks depend on different cognitive processes. The ENT measure places more demands on working memory than the AVToM because participants had to choose between embarrassed and neutral facial expressions *after* they viewed the narrative. Therefore, participants must remember the story when making responses on the test slide. This is different from the AVToM in which participants were shown both context and facial expressions simultaneously. Overall, the correlation between the ENT and AVToM suggests that both of these measures assess similar aspects of ToM, although differences in processing demands may have weakened the relationship between the two tasks.

In addition to the associations between some of the ToM tasks, positive correlations were also found between specific emotion types on the affective ToM measures. Happy trials on the AVToM task were related with overall performance and with performance on embarrassing trials on the ENT. One possible explanation for this result is that the emotion of embarrassment may include aspects of humor. Although committing an embarrassing act would make an individual feel awkward, witnessing an embarrassing situation may be humorous for the surrounding audience. One way to test this hypothesis would be to assess an individual's emotional state via questionnaire both before and after completing the ENT. If participants found the embarrassing situations humorous then there may be an increase in positive affect post-test. It would also be possible to partial out the scores on the questionnaire to see if this happy-embarrassed relationship remains. If the relationship between the two emotions drops to non-significance, then the only reason as to why these emotions are related is because both emotions trigger positive affect.

Contrary to prior predictions, the ENT task was not related to either the FPRT or the RME. The lack of relationships between these tasks suggests that although the ENT was designed to assess affective components of mentalizing, it may not be a true assessment of ToM. However, the ENT did correlate with the AVToM, which suggests that both tasks are assessing similar aspects of the mentalizing system. Perhaps differences in task presentation and task demands overshadowed any commonalities between the measures. For example, while the FPRT is a purely linguistic task, the ENT is a visually-based assessment. In addition, response time data were collected for only the ENT and therefore participants were instructed to respond as quickly as possible. However, no temporal constraints were placed on either the FPRT or the RME task. The ENT also places greater demands on working memory compared to the other measures because participants made their responses after viewing the narrative. In the FPRT, participants were given copies of the vignettes and were allowed to refer back to the story at any time during the question period. Similarly, in the RME task, participants were shown images and mental state options concurrently.

The ToM tasks utilized in the current study may be differentially assessing cognitive and affective domains of ToM. Although significant relationships were found between some of the ToM measures, the correlations between the tasks were relatively low, ranging from $r = 0.23 – 0.28$. Weak correlations between the measures suggest that although each task may be tapping aspects of ToM, there are critical differences among the measures as well. These differences may be because performance on each measure is dependent upon different cognitive processes (Ahmed & Miller, 2011), or because each task is measuring different components of ToM (Shamay-Tsoory *et al*., 2005).

The Dissociation of ToM

Surprisingly, very little research has been conducted specifically examining the associations between the numerous ToM tasks (Brent, Rios, Happe, & Charman, 2004). The measures that currently assess ToM in both adults and children are very different from one another. While the FPRT involves detecting a social faux pas, the ‘Strange

Stories' test involves reading short vignettes that assess the ability to recognize aspects such as lies, or sarcasm (Happe, 1994). Similarly, the 'Hinting Task' also involves reading short stories and trying to recognize the true intentions of the main character (Corcoran, Mercer, & Frith, 1995). There are also tasks that involve extracting mental state information from cartoon drawings (Shamay-Tsoory & Aharon-Peretz, 2007). In regards to emotional ToM, the 'Awkward Moments Test' assesses the capacity to recognize embarrassment (Heavy *et al.,* 2000). Some researchers have also modified the RME measure to create the 'Reading the Mind in the Voice Task' (Golan, Baron-Cohen, Hill, & Rutherford, 2007) and the "Reading the Mind in Films Task' (Golan, Baron-Cohen, & Golan, 2008). Clearly these tasks differ in regards to which aspects of ToM they are assessing (cognitive versus affective), task presentation (visual, auditory, or verbal) and the demands placed on cognitive processing. With such vast differences between ToM assessments, it is surprising that researchers have not yet examined the relationships between these various ToM measures (Brent *et al*., 2004).

Ahmed and colleagues (2011) investigated the association between the FPRT, the RME, and the Strange Stories task, and found that *none* of the tasks were significantly correlated with one another. Interestingly, different components of executive functioning such as problem solving or deductive reasoning were differentially related to the ToM measures. This result led the researchers to suggest that "... there may be differing cognitive processes that are associated with the apparent different domains of ToM measured by each test" (p. 675). This assertion is supported by the findings of Brent and colleagues (2004) in which the children's version of the RME, the Strange Stories task, and a ToM cartoon task were not significantly associated with one another. These researchers also suggest that the lack of association between the ToM tasks may be due to differences in processing demands. Surprisingly, there are a number of researchers investigating ToM understanding that have either not found relationships between ToM tasks (Ahmed *et al*., 2001; Brent *et al*., 2004; Bora, *et al*., 2005; Gregory, Lough, Stone, Erzinclioglu, Martin, Baron-Cohen, & Hodges, 2002; Heavey, *et al*., 2000; Kaland *et al*., 2008; Roeyers, Buysse, Ponnet, & Pichal, 2001; Shamay-Tsoory *et al*., 2005; Spek & Scholte, 2010) or, if a relationship was reported, the correlation was moderate or weak (Ferguson *et al*., 2010; Golan *et al*., 2007; Kim, Kwon, & Chang, 2011; Shamay-Tsoory *et al*., 2005; Spek & Scholte, 2010). These studies are listed in Table 12.

Table 12.
Correlations between ToM measures reported in different studies.

Study	Comparison	*r*	*p-value*
Ahmed & Miller (2011)	FPRT-RME RME–SST FPRT–SST	0.13 0.14 0.11	ns ns ns
Brent Rios, Happe & Charman (2004)	cRME-SST	0.36	ns
Bora *et al.,* (2005)	RME-HT	not reported	ns
Ferguson & Austin (2010)	FPRT-RME	0.28	<0.01
Golan, Baron-Cohen, Hill, Rutherford (2007)	RME-RMV	0.39	<0.01
Gregory *et al*., (2002)	RME-1stFB RME-2ndFB	not reported not reported	ns ns
Heavy, Phillips, Baron-Cohen & Rutter (2000)	AMT-SST	0.48	ns

Kaland, Callesen, Nielsen, Mortensen & Smith (2008)	RME-SST RME-SEL	0.27 -0.11	ns ns
Kim, Kwon, Chang (2011)	FERT-RME	0.42	ns
Roeyers, Buysse, Ponnet & Pichal (2001)	RME-SST	0.33	ns
Shamay-Tsoory, Tomer, Berger, Goldsher & Aharon-Peretz (2005)	FPRT-DIT FPRT-AP	0.247 0.34	0.04 ns
Spek, Scholte, & Van Berckelaer-Onnes (2010)	FPRT-RME RME-SST	-0.18 0.226	ns ns

FPRT = Faux Pas Recognition test (FPRT); RME = Reading the Mind in the Eyes Task; SST = Strange Stories Task; cRME = Children's version of the Reading the Mind in the Eyes Task; HT = Hinting Task; RMV = Reading the Mind in the Voice Task; 1stFB = First-Order False Belief Task; 2ndFB = Second Order False Belief Task; AMT = Awkward Moments Test; SEL = The Stories from Everyday Life Task; FERT = Facial Emotion Recognition Task; DIT = Detection of Irony Task; AP = Affective Prosody Task.

Another reason why ToM researchers have reported low correlations between ToM measures is because each task may be assessing different domains of the mentalizing system (Kaland *et al*., 2008). As previously discussed, ToM can be dissociated into cognitive and affective components (Shamay-Tsoory *et al*., 2005). Although both affective and cognitive information can be integrated in order to assess the mental state of another individual and to predict behaviour, recent research has suggested that the two domains may be processed by separate but overlapping neural systems. For example, while damage to the amygdala in the left hemisphere disrupts the ability to make belief attributions, damage to the amygdala in the right hemisphere disrupts affective ToM (Fine *et al*., 2001; Shaw, Lawrence, Radbourne, Bramham, Polkey, & David, 2004). Recent research has also found that patients with temporal lobe epilepsy perform poorly on ToM measures, particularly the tasks assessing emotion recognition (Broicher, Kuchukhideze, Grunwald, Kramer, Kurthen, & Jokeit, 2012).

Areas of the frontal lobe can also be separated into regions that process cognitive or emotional ToM. For example, the orbitofrontal cortex, primarily medial portions, is involved in the ability to judge another person's affective state (Hynes, Baird, & Grafton, 2006). In addition, patients with damage to the ventromedial prefrontal cortex score poorly on tasks assessing empathy (Shamay-Tsoory, Tomer, Berger & Aharon-Peterz, 2003), which has been shown to be fundamentally related to ToM (Baron-Cohen, 2002). Lesions in the ventromedial prefrontal cortex also disrupt affective ToM reasoning (Shamay-Tsoory *et al*., 2005; Shamay-Tsoory, & Aharon-Peretz, 2007). It has also been suggested that this region is a place of convergence for cognitive and affective ToM information (Shamay-Tsoory *et al*., 2005). Finally, Shamay-Tsoory and Aharon-Peretz (2007) have suggested that studies that have found dorsomedial prefrontal activity in ToM reasoning utilized cognitive ToM tasks, suggesting that this area is specifically involved in cognitive ToM. What the research reviewed here suggests is that the neural substrates involved in ToM reasoning can be dissociated based upon the different domains of mentalizing.

Based on the research previously discussed, Abu-Akel and Shamay-Tsoory (2012) developed a neural model of ToM in which there are separate but interconnected networks that process cognitive and emotional ToM. The areas that process cognitive ToM information include dorsal regions of the forebrain (i.e., the striate nucleus), anterior cingulate cortex, and the medial prefrontal cortex. The neural substrates that are involved in affective ToM include ventral portions of these same areas, with the addition of the amygdala. This neural model of mentalizing suggests that ToM reasoning can be broken down into cognitive and affective subcomponents. Perhaps ToM understanding can be differentiated even further based upon the processing demands of various mentalizing tasks (Ahmed & Miller, 2011; Brent *et al.,* 2004). The dissociation of ToM reasoning may be one of the reasons why the current study found weak, or non-existent, correlations between the measures. The tasks used in the current study (i.e., AVToM, ENT, FPRT, and RME) differ according to the emphasis each test places on affective and cognitive aspects of ToM understanding. Therefore, the findings of several behavioural studies which have found that ToM tasks can be differentiated from one another based upon processing demands may be reflecting the fact that different domains of ToM (i.e., cognitive versus affective) are processed by distinct (yet overlapping) regions of the brain. In addition, based on the notion that the development of ToM can be separated into numerous components such as learning to use eye-gaze information, perspective taking, emotion attribution, and desire reasoning, it makes sense that ToM in adults is also a multi-dimensional concept.

Verbal Ability and ToM Reasoning

The dissociation of ToM is further supported by the finding that the tasks used in the current study were differentially related to verbal skill. The second goal of the present study was to assess whether linguistic ability is associated with performance on both verbal and non-verbal ToM measures. The NAART was chosen as the verbal task for this study because it has been extensively used to assess verbal intellect in a number of different clinical populations (Bright, Jaldow, & Kopelman, 2002), and performance on the NAART is similar to performance on other well established verbal measures, such as the WAIS-R vocabulary test (Uttl, 2002). Consistent with previous predictions, performance on the NAART was significantly related to performance on the RME. Since the NAART assesses vocabulary and word-reading ability, and the RME involves matching verbal labels to pictures of eyes, it makes sense that the two measures are related. This is consistent with the finding that word-reading ability predicts scores on the RME task (Ahmed & Miller, 2011) and is a decided weakness of the RME measure. The association between the RME task and verbal skill suggests that this test may not be purely assessing mentalizing abilities but linguistic ability as well. Importantly, clinical populations with language disturbances may perform poorly on the RME task because performance is based on having an extensive vocabulary, not necessarily because they have ToM deficits.

Unexpectedly, scores on the NAART were also correlated with scores on the AVToM task. Based on the fact that the AVToM has no verbal components, this relationship is surprising. Perhaps similar cognitive processes are required in order to complete the two tasks. Words on the NAART are irregularly spelled; therefore, accurate pronunciation is based on the participants' knowledge of the word. However, if participants had come across unfamiliar items on the test they may have resorted to phonological strategies such as breaking down the words into individual speech sounds, or phonemes, and then re-combining them in order to make their best guess at the pronunciation (Bradley & Bryant, 1983; Frost, 1998; Schotter, Angele, & Rayner, 2012) Similarly, the AVToM involves analyzing a complex visual scene; participants may have had to break down the images into different components, separating the emotional facial expressions from the contextual information. Once participants understood the scenario portrayed in that particular trial, they would have had to re-combine context with the appropriate emotional facial expression in order to choose the correct photo.

Contrary to previous hypotheses, no relationship was found between the NAART and the FPRT. This is surprising given the fact that performance on this test is based upon both receptive and expressive verbal ability. Although the NAART is thought to be a valid measure of verbal skill and has been used extensively in studies of different clinical populations, this test may only be assessing one particular aspect of language– vocabulary. Fergusen & Austin (2010) also found that vocabulary is not related to performance on the FPRT. Therefore, performance on this task may depend on other linguistic skills, perhaps syntactic understanding or reading comprehension. Interestingly, previous research has shown that the ability to produce semantically-related words within a given time frame (i.e., verbal fluency) is correlated with performance on the FPRT in adults (Ahmed *et al*., 2011). The relationship between language and ToM understanding had been debated for a number of years with some authors stressing the importance of semantic ability (Moore *et* al., 1990), syntactic understanding (Astington & Jenkins, 1999; de Rosnay, Pons, Harris, & Morell, 2004; de Villiers & de Villiers, 2000; de Villiers & Pyers, 2002; Lohman, & Tomasello, 2003; Pons, Lawson, Harris, & de Rosnay, 2003), vocabulary (Farrar & Maag, 2002), and general linguistic skill (Cheung, Hsuan-chih, Creed, Ng, Wang, & Mo, 2004; Jenkins & Astington, 1996; Milligan, Astington, & Dack, 2007; Slade & Ruffman, 2005; Ruffman *et al*., 2003). Importantly, it has been suggested that language is more important for the development of ToM reasoning in children and is less pertinent in adult mentalizing (Apperly, Samson & Humphreys, 2009). What the research reviewed here suggests is that future studies should include *multiple* measures of linguistic ability in order to better understand the role of language in different ToM tasks. Just as different components of language may be differentially related to various ToM measures, the speed at which individuals' process mental state information may differ depending on which specific aspects of mentalizing a ToM measure is assessing.

Response Time on the ENT task

The third goal of the present study was to examine whether there are differences in processing speeds when recognizing the emotion of embarrassment. As previously discussed, identifying belief-based emotions, such as embarrassment, is more difficult than identifying simple emotions such as sadness or happiness because of the added requirement of recognizing alternate beliefs or perspectives. In addition, previous research has found that response times are significantly longer when participants answer questions regarding the mental states of other individuals in comparison to control questions (Kaland *et al*., 2002). Based on these findings, it was hypothesized that participants would require longer periods of time in order to correctly identify embarrassing as opposed to neutral scenarios in the ENT task. Contrary to prior predictions, no significant differences were found in responses latencies. There are two possible explanations for this null result. First, it is possible that recognizing embarrassment is not as difficult as previously hypothesized. For instance, Hadwin and Perner (1991) found that children begin to recognize belief-based emotions such as surprise as early as five years of age. Due to the fact that the participants in this study were adults, they may have performed this task effortlessly. This was certainly the case for a subset of the participants in this study; however, many participants also found this task to be extremely difficult. These large individual differences increased the variability of the results, thereby decreasing the likelihood that a significant statistical difference would be detected. Second, it is possible that elements of the ENTs design may also have limited the ability to detect a difference between the two conditions. One trial in the ENT task consisted of two slides: the first slide depicted the neutral or embarrassing story and the second slide showed the main actor express two different facial expressions. Importantly, response time data were only collected for slide 2. It is possible that participants had already made decisions regarding the affective state of the story's protagonist *before* slide 2 was presented. By collecting RT data exclusively on slide 2, this task may not have been assessing the 'on-line' processing of ToM, and therefore may not have captured differences in processing speeds in the identification of embarrassing versus neutral narratives. It may have been more appropriate to collect RT data on slide 1, when the narratives were presented. This methodological change would allow us to assess differences in initial processing times, and would have enhanced our ability to detect additional performance differences between males and females.

Sex Differences

The final goal of the present study was to examine whether there are sex differences in performance on each of the ToM measures. Previous research has found that females score higher than males on the FPRT (Ahmed & Miller, 2011; Baron-Cohen *et al*., 1999), the RME (Baron-Cohen *et al*., 1997, 20001), and on measures assessing empathy (Baron-Cohen, 2002). However, in this study no significant performance differences were found between males and females on either the FPRT or the RME. Therefore, contrary to previous research, males and females were equal in their ability to detect a faux pas and to match mental state terms to pictures of the eye region of the face.

The extreme male brain hypothesis (EMB) states that men and women differ in terms of the strategies they employ when solving ToM tasks; while men rely more on systemizing strategies (i.e., set of rules for appropriate social behaviour), women depend more on the empathizing system (i.e., recognizing and experiencing an individual's emotional state) (Baron-Cohen, 2002). In addition, previous research has found that females score higher than males on tasks assessing emotional recognition (Hall, Gaul, & Kent, 1999; Hall & Matsumoto, 2004; McClure, 2000; Thayer & Johnsen, 2000). Based on the EMB hypothesis and on previous research, it was hypothesized that females would outperform males on the affective ToM tasks. Although there was a trend for females to score higher than males on the AVToM and ENT measures, these differences were not statistically significant. The lack of sex differences found in the current study suggests that although men and women may differ in terms of the cognitive and affective strategies employed during ToM reasoning, both sexes are equally able to infer to mental states of other individuals. Thus, men and women may use different 'routes' during ToM reasoning but in the end, draw similar conclusions about the cognitive and emotional states of other individuals.

Although no significant sex differences were found on overall performance on the ToM tasks, subsequent analysis of different emotion types found that females were significantly more accurate in recognizing fearful scenarios in the AVToM task. While previous studies have shown that women tend to produce higher scores on tests assessing various affective states, recent research has suggested that women are particularly more adept at identifying unpleasant or negative emotions. Montagne and colleagues (2005) showed participants videos in which neutral facial expressions slowly transitioned into various emotional expressions. The researchers found that females were more accurate and took less time to identify sad, angry, and disgusted facial expressions. Other lines of research have found that women tend to rate emotional pictures as fearful more than any other emotional category (Arindell *et al*., 2003; Barke, Stahl, & Kroner-Herwig, 2012). Barke and colleagues (2012) showed participants various emotional scenes and asked participants to categorize images according to emotion type such as sad, fearful, joyful, disgusted, or surprised. The results of this study indicated that women were more likely than men to categorize images as 'fearful'. In summary, although the results of the present study did not find an advantage for females on overall performance on the ToM tasks, it may be that females are better at identifying specific emotions (i.e., fearful) compared to males.

Study Limitations and Future Directions

Although attempts were made to account for as many variables as possible, the current study had some limitations. First, all the participants were first-year university students and therefore were of similar age and education level. Thus, the results of the present study may not be generalizable outside of this specific population. In addition, no screening was completed in order to identify participants with learning disorders, or those diagnosed with autism or Asperger's syndrome. The current study also did not control for specific cognitive processes that have been shown to be related to ToM reasoning such as executive functioning (Ahmed *et al*., 2011; Carlson & Moses, 2001), or working memory (Dennis, Agostino, Roncadin, & Levin, 2009; Mutter, Alcorn, & Welsh, 2006). Finally, scores on the NAART were well below established norms reported for this age group. The low verbal ability of the sample used in the present study may have affected the relationships between the NAART and the ToM tasks.

The findings of the present study provided valuable insights into the problems facing current ToM research. The low, or non-existent, correlations between the ToM measures used in the present study supports the notion that ToM tasks are assessing diverse components of mentalizing. In the future, a large-scale study should be conducted specifically examining different ToM measures and how they relate to one another. This study should have a large sample size for both males and females in order to detect sex differences on these tasks. Without this important information, it will be impossible for ToM researchers to know whether they are utilizing a task that *truly* assesses ToM, or which domain of ToM a particular measure is assessing. Furthermore, in order to elucidate the relationship between ToM and language, future research should focus on how different ToM tasks relate to multiple components of language (e.g., syntax, semantics, reading ability, verbal fluency). Research into this area would provide further insight into which specific components of language are important for cognitive or affective ToM reasoning, and would help resolve the issue of whether ToM reasoning is dependent upon linguistic abilities. For instance, although vocabulary was not mediating the relationships between the ToM tasks in the current study, this verbal component did influence performance on some of the ToM measures, particularly the RME task. In addition, other areas of verbal skill such as verbal fluency may be more strongly related to the ToM measures used in the present study. In summary, the concept of ToM needs to be more accurately specified and defined before researchers continue to investigate ToM disturbances in clinical populations, such as individuals with autism.

Conclusion

The current study extended previous research by creating two non-verbal ToM measures aimed at assessing affective mentalizing in adults. Both of these measures, the AVToM and the ENT, were designed to reflect real-world scenarios by having context embedded within the tests. The main goal of this experiment was to examine whether these two non-verbal measures assess mentalizing abilities similar to those assessed by existing language-based measures. Positive correlations were found between the FPRT and RME, the AVToM and FPRT, and the AVToM and ENT. Importantly, verbal ability was not mediating the relationships between these ToM measures. These results support the hypothesis that the AVToM and ENT tasks assess mentalizing abilities. However, the weak relationships found between the measures was a cause for concern and highlights the fact that different ToM assessments are not only examining different components of ToM (Shamay-Tsoory *et al*., 2005), but that performance on each task is dependent upon different cognitive processes (Ahmed *et al.,* 2011). Therefore, the current study supports the hypothesis that ToM is not a unitary concept, but can be dissociated into a number of different, but related, components.

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