# Typically Developing and Autistic Children's Understanding Across Both Naïve Psychology and Naïve Biology

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## ABSTRACT

### Typically developing and autistic children's understanding across both naïve psychology and naïve biology

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The objective of this thesis was to examine the development of and interface between naïve psychology and naïve biology. The main body of this thesis is composed of two articles submitted for publication. In the first paper, infants completed a generalized imitation task at 16 or 20 months of age which assessed their ability to generalize target properties to animate and inanimate beings. These infants returned to the laboratory at five years of age and were administered a battery of five ToM tasks an animacy-acceptability task and the Peabody Picture Vocabulary Test-III. In the second experiment, infants participated in another generalized imitation task at 16 or 20 months of age which assessed their ability to generalize psychological properties to the appropriate animate domain. At six years of age, these children were administered a ToM battery, a task designed to measure the understanding of the essential properties of living and non-living kinds and the PPVT-III. Taken together, the results of these two longitudinal studies indicate continuity between the early understanding of the Animate-Inanimate (A-I) distinction and later knowledge of Theory of Mind at preschool age. In addition, infants' ability to form an A-I distinction was linked to a more advanced understanding of animacy at preschool age, supporting the proposal that the A-I distinction in infancy might be a potential precursor to later naïve biology.

In the second paper, the focus was on young autistic's children's ability to form an A-I distinction. A sequential touching task was administered to a group of typically developing 18-month-old infants and to a group of young autistic children. The typically developing children successfully categorized at the domain level (e.g., animates vs. inanimate objects). In contrast, the children with ASD successfully categorized at the global (e.g. animals and vehicles) but not at the domain level. Importantly, these results indicate that typically developing infants can form categories at a higher level of inclusiveness than has previously been demonstrated. As well, the findings suggest that autistic children do indeed possess a concept of animacy, although the breadth of this knowledge may be narrower than that of typically developing children.

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# CHAPTER 1: GENERAL INTRODUCTION

## General Introduction

Research on how children come to understand their mental world and that of others, has been performed under the rubric of 'Theory of Mind' (ToM), 'naïve psychology', or more broadly 'folk psychology'. More specifically, ToM has come to refer to the developmental understanding of mental states such as beliefs, intentions, desires, and emotions and to the ability to then reflect upon and reason about these mental states in oneself and others. The notion of a ToM presents a framework to study children's conceptual knowledge from a social cognitive perspective and has become an increasingly prevalent focus of empirical research in developmental psychology over the last two decades.

A number of theories have been proposed as explanations for children's understanding of the mental world. The modularity account of ToM focuses on early competence with its premise being that children's theory of the mental world has a specific, innate basis (Leslie, 1987). Researchers who endorse the modularity account posit that ToM is best conceptualized as a cognitive module that exists as a distinct ability that is independent and functionally separate from other cognitive skills (Baron-Cohen, 1995; Scholl & Leslie, 1999; 2001). Research on autism, a neurological disorder characterized by social-communicative difficulties, has strengthened the notion of ToM as a separate and domain specific ability. More specifically, impairment in ToM has been used to explain the core social and communicative deficits specific to Autism. Evidence of a deficient ToM relative to other cognitive functions, as is the case in autism and

Asperger's syndrome, supports the modular view of ToM as a specialized cognitive skill (Baron-Cohen, 1995; Baron-Cohen, Leslie, & Frith, 1985). Further, the modularity account of children's understanding of the mind considers maturation as the mechanism that explains the development of ToM. In contrast to the modularity account of ToM, the 'theory theory' perspective focuses on conceptual change (Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1994). Theory theory conceptualizes ToM as a gradually developing and evolving conceptual theory that is largely influenced by the child's experiences. Theory theory does not view ToM as an innate ability nor as a specific cognitive module, but rather as a specialized skill reliant upon more general cognitive processes involved in knowledge formation (Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1994). As a result, ToM is thought to develop gradually, as a series of stages which culminate in a mature ToM.

The theory theory model of ToM has important implications for the origins of naïve psychology during the early developmental years (Poulin-Dubois, Brooker, & Chow, 2009). More specifically, the notion of ToM as gradually developing through a series of steps lends itself to an analysis of how each step may influence and contribute to the next one. Because one of the objectives of the first paper in the present thesis is to examine whether continuity exists between infants' rudimentary understanding of the human mind and the more developed form of ToM abilities seen at later ages, a brief review of the empirical evidence that supports the notion of ToM as a gradually developing understanding of the mind is presented.

The first to have introduced the term "Theory of Mind" were Premack and Woodruff (1978) who explored whether non-human primates possess a ToM. In the thirty years since Premack and Woodfruff's groundbreaking paper, a plethora of studies has been conducted examining how and when children come to experience mental states such as desires, perceptions, emotions, and beliefs. The general consensus of these empirical investigations is that important changes take place in children's understanding of the mind between the ages of three and five, with a significant milestone being the understanding of false-belief at around age five.

During these early developmental years, children gradually move from having acquired basic visual perspective-taking skills by two years of age in which they understand that the same object can be viewed differently by different people (i.e. they appreciate that another person may not see what they see and vice versa) (Flavell, 1992), to a more complex visual perspective-taking ability at around three years of age in which they understand that one's visual perspective of an object influences how the object appears (i.e. the same object can result in different visual perceptions for people depending on the position from which it is viewed) (Flavell, 2000). At around this time, two-year-old children also begin to consider the desires of another person and can reason about others' desires when interpreting behaviors. For instance, two-year-old children can correctly predict a person's actions by taking into account his or her desires (Wellman & Wooley, 1990). By three years of age desires become associated with emotions and children understand that desires, perceptions, and emotions are interconnected (Wellman, Phillips, & Rodriguez, 2000). Children at this age also begin to use belief terms, such as "want" and "like" and consider beliefs to be mental representations, though have yet to form a causal connection between beliefs and actions (Poulin-Dubois et al., 2009). However, at four years of age, a belief-desire theory is well established whereby children understand that beliefs and desires interact with each other to generate intentions, and these intentions can guide behavior (Bartsch & Wellman, 1995; Wellman, 1990).

These accomplishments culminate in the ability to distinguish true and false beliefs, as evidenced by the ability to pass false-belief tasks. In the classic version of the false-belief task (Wimmer & Perner, 1983), a child witnesses a first character leave a room after having placed a ball in a specific location (e.g. a basket). As the first character remains outside the room, the child witnesses a second character move the ball to another location (e.g. a box). The first character is then made to re-enter the room, whereupon the child being tested is asked where this character will look for the ball. To answer correctly, children must understand that the character has a mistaken belief (one that is different from reality and from their own knowledge) of where the ball is and answer that the character will look in the basket even though the ball is really in the box. Research has demonstrated that normally developing four- to five-year-old children succeed on variations of this task, providing remarkable evidence of understanding representational mental states (Wellman, Cross, & Watson, 2001).

The various developmental stages that result in a full-fledged ToM at five to six years of age are thought to develop sequentially and to build upon each other in a cumulative fashion such that each earlier skill is a developmental prerequisite for a subsequent, more complex ability (Wellman & Liu, 2004), and to be “driven by the accumulation of data and information through experience” (Poulin-Dubois et al., p.61). In summary, there is mounting evidence that during these formative early years, children begin to attribute psychological states such as desire, perception, and emotion to people, at least at an implicit level (Meltzoff et al., 1999).

Because the theory-theory account focuses on conceptual changes and posits that an emerging ToM involves important changes (Gopnik & Wellman, 1994), it lends itself to empirical investigations on the nature and *origins* of such changes. Indeed, researchers in the field of naïve psychology have attempted to explore the links between children's early abilities and their later, more developed understanding of psychological states as described above. One of the initial manifestations of ToM might be evident in infants' early awareness of other people. From a very young age, this awareness is identifiable in infants' tendency to recognize diverse facial expressions and make use of this information to regulate behavior. For instance, 12 month-old infants have been found to act positively versus hesitantly toward objects depending on the emotion displayed by another person (Sorce, Emde, Campos, & Klinnert, 1985). As well, electrophysiological research has demonstrated that infants as young as seven months readily discriminate angry from fearful facial expressions (Kobiella, Grossmann, Reid, & Striano, 2008).

The ability to follow eye gaze and subsequently detect a person's goal is also instrumental in the development of a ToM. Indeed, research has shown that nine to 14 month-old infants begin to successfully follow another person's gaze (Butterworth, 1991) and become upset when people do not behave actively and contingently (Muir & Haines, 1993). Further, in a recent study examining whether infants understand that a person's action goals are influenced by perception, Luo and Johnson (2009) found that six month-old infants did indeed consider what a person could see when interpreting the person's actions toward an object, such as reaching or grasping the object. In light of such findings, the ability to follow eye gaze has been proposed as a necessary antecedent to engaging in joint-attention, a skill considered to be a precursor to ToM.

Since infants' early ability to imitate other people's behavior has significant implications for the development of social cognition (Meltzoff, 2007), the early manifestation of imitation has been put forward in the literature as another potential building block for the development of a ToM. Early research demonstrated that two- to three-week-old newborns are capable of consistently imitating facial (tongue protrusions) as well as manual (finger movement) gestures performed by another person (Meltzoff & Moore, 1977). These results were replicated in a subsequent study whereby six-week-old infants reliably imitated facial gestures 24 hours after having seen an adult perform those gestures (Meltzoff & Moore, 1994). According to Meltzoff (2007), infant imitation entails observing another's actions and construing those actions as corresponding to their own behaviors, thereby making a connection between their own states and those of others. In light of this model, imitation of other people's actions and behaviors could be viewed as a significant stepping-stone towards the development of a mature ToM.

Taken together, the research to date on infants has provided evidence for the manifestation of a number of behaviors such as joint visual attention, social referencing, and imitation suggestive of an emerging understanding of others as intentional agents (Poulin-Dubois, 1999). This research on how children begin to conceive others as purposeful, intentional agents has prompted an increased interest in the developmental precursors to such achievements during the first two years of life. As such, the search for antecedents and precursors of ToM with the use of longitudinal designs has significantly contributed to our understanding of the developmental progression in children's understanding of mental states from infancy to preschool age. Indeed, a number of significant abilities, such as joint attention (Tomasello, 1995), understanding the intentions of others (Meltzoff, 1995), pretence (Leslie, 1987, 1994), and imitation (Rogers & Pennington, 1991), have been proposed as putative precursors to the development of a full-fledge ToM.

While there is relatively less empirical research in favor of these proposed precursors of a ToM, a number of longitudinal investigations have been conducted examining children's early experiences and knowledge and their subsequent understanding of mental states (e.g. Carpenter, Nagell & Tomasselo, 1998; Charman et al., 2000; Olineck & Poulin-Dubois, 2005, 2007; Youngblade & Dunn, 1995). For instance, Yamaguchi, Kuhlmeier, Wynn, & vanMarle (2009) examined whether there exists developmental continuity between performance on a social cognitive task which assessed infants' understanding of goal-directed actions and ToM knowledge at preschool age. The authors found that while performance on a non-social cognitive task did not predict later ToM performance, performance on the social task in infancy, specifically the ability to comprehend goal-directed behavior at 12 months of age, did indeed predict ToM performance at four years of age. In a related study, Aschersleben, Hofer, and Jovanovic (2008) found that the ability to interpret actions as goal-directed at six months of age was linked to the later ability to attribute mental states, as measured by the ability to pass a false belief task at four years of age. These results were consisted with those of Wellman, Lopez-Duran, LaBounty, and Hamilton (2008) as well as Olineck and Poulin-Dubois (2005, 2007) who also found a longitudinal association between attention to intentional action in infancy and later development of ToM. In summary, evidence from these longitudinal studies does seem to support the view that continuity exists between observing and interpreting others' behavior as intentional and goal-directed in infancy and later social understanding at preschool age. Several other longitudinal studies performed over the last number of years have also found that additional infant abilities such as pretense (Youngblade & Dunn, 1995) and joint attention (Charman et al., 2000) are critical precursors to the development of theory of mind.

Overall, these findings are promising and point to early infancy as an important developmental period for ToM. Nonetheless, large gaps remain in our knowledge of the initial steps of naïve psychology. Future research is needed to further support the evidence presented thus far for the hypothesis that the origins of ToM knowledge lie in specific early infant abilities. Namely, studies are needed that expand upon the question of precursors of ToM in infancy by examining additional infant abilities that could be potential early indicators of later ToM. As such, the primary goal of the first paper in this thesis was to further examine the continuity hypothesis in a more systematic manner through a series of two longitudinal experiments carried out from infancy to the preschool period by examining whether infant's biological understanding of the differences between animate and inanimate beings might be linked to later ToM knowledge.

## Children's Knowledge of Naïve Biology

Over the last two decades, a great deal of attention has been devoted to children's early cognitive development and their increasing understanding of their surrounding world. Particular attention has been paid to children's knowledge in core domains of thought, such as naïve psychology (e.g. Gopnik & Wellman, 1994; Wellman & Gelman, 1998), naïve physics (e.g. Carey, 1985; Carey and Spelke, 1994), and naïve biology (e.g. Hatano and Inagaki, 1994). The research reviewed thus far on children's naïve psychology and their understanding of the mental world raises intriguing questions about children's related knowledge of naïve biology and their understanding of biological phenomena. As such, the first paper of this dissertation sought to explore the extent of children's understanding across both naïve psychology and naïve biology. More specifically, the question of whether the understanding of mental states such as desires, intentions, and beliefs during preschool years draws upon an earlier understanding of the biological differences between animates and inanimates was explored.

Children's knowledge of naïve biology has raised considerable research attention (Carey, 1985; Inagaki & Hatano, 2002). In particular, research in the field has focused on preschoolers understanding of biological phenomena such as the concepts of inheritance, internal bodily processes, illness and contamination, and knowledge of the differences between living and nonliving things. What follows is a brief review of this body of work to date.

Children's reasoning about inheritance has become a major focus in the scientific search for the origins and developmental progression of the understanding of naïve biology in childhood (Williams & Smith, 2006). One of the first studies examining children's understanding of biological inheritance was conducted by Gelman and Wellman (1991). In this study, four-year-old children were told of a situation in which a baby animal was separated at birth from its family and subsequently raised by a different species. For instance, children were shown a picture of a baby cow and were informed that the baby cow was raised exclusively by pigs, at which point they were presented with a picture of pigs on a pig farm. The children were then asked a series of questions regarding the target animal's (i.e. the cow) characteristics once it grew up. The questions were designed to assess children's understanding of the target animal's category membership based on non-observable attributes, such as, in the cases of the cow for example, its future tail shape (straight versus curly) and the sound it would emit ('oink' versus 'moo'). Results showed that preschool age children answered that a cow reared among pigs will have a straight tail when it grows up and will say 'moo', indicative of knowledge of category membership based on innate potential such as inheritance. A number of studies have added credence to Gelman and Wellman's (1991) findings by establishing that preschool age children do indeed expect offspring to bear a resemblance to their birth parents and to share certain biological properties with them (Hirschfeld, 1995; Springer, 1992, 1995). While such studies do indeed support the idea that children have an understanding of biological inheritance and possess a rudimentary grasp of the mechanisms of inheritance (Springer & Keil, 1991), other research has presented conflicting findings on the extent of preschooler's understanding of biological inheritance (e.g. Solomon et al., 1996). Instead, it has been argued that children's knowledge of certain factual information related to biological inheritance does not signify the existence of a domain-specific theory of biology (Solomon, 1998; 2002). Notwithstanding this line of reasoning, it is clear from the literature that young children do indeed have a biological understanding of inheritance to some extent.

Children's understanding of biology includes knowledge of processes other than inheritance, such as that of illness and contamination. In assessing children's comprehension of the concept of illness, researchers have mainly looked at preschooler's understanding of germs and whether they recognize that certain illnesses can be genetically transmitted (Raman & Gelman, 2005). Springer and Ruckel (1992), for instance, showed that four- to five-year-old children think of illness as a result of coming into contact with contaminants such as germs, and not as a consequence of misbehaving.

Additional support for children's biological understanding of illness was provided by Kalish (1996) who found that four-to-five year old children consider the presence of germs to be a determining factor in whether contamination will lead to the onset of illness. More recently, Raman and Gelman (2005) found that by the time children reach preschool age, their understanding of illness becomes more sophisticated. More specifically, the authors found that preschoolers had an understanding that genetic disorders are transmitted differently (i.e. though a hereditary predisposition) than are contagious illnesses. While research to date suggests that preschoolers have amassed key biological information about health and illness, the extent to which this information is linked to causal mechanism of transmission and subsequently integrated into a biological 'theory' is less clear (Au & Romo, 1999; Solomon & Cassamatis, 1999).

Children's ability to distinguish between living and non-living things is also an important part of their overall theory of biology. According to Inagaki and Hatano (2002), children as young as five years of age are capable of distinguishing living from non-living things, including animals and plants. Furthermore, by preschool age, children have formed an understanding that the capacity for goal-directed movement is an essential determinant for the concept of living things (Opfer & Siegler, 2004). For instance, Opfer (2001) found that by five years of age, children attributed life status to unfamiliar entities only when these were made to move on their own in a goal-directed manner and not when they appeared to move in an autonomous but aimless manner.

Thus far, the picture of children's understanding of biological phenomena is an interesting, yet incomplete, one. There does appear to be substantial evidence to suggest that *preschoolers* have a basic level understanding of the biological world. What remains unknown however is the extent to which younger children have an initial understanding of the natural world that is indicative of their later, fuller awareness of naïve biology. Indeed, the research to date has focused virtually exclusively on preschoolers' understanding of the biological world, with little information on the roots of this knowledge in infancy. Surely, if preschoolers can reason about concepts such as inheritance and illness, then such thought processes about important aspects of naïve biology might also be evident in early childhood. And yet, unlike the field of naïve psychology which has noticeably explored the roots of mental understanding in infancy, the field of naïve biology has failed to provide any comparative knowledge on the origins of naïve biology.

Perhaps the only infant ability that has been proposed as a precursor for later knowledge of biology is the detection of animacy cues. Research demonstrating that infants are capable of discriminating animate (e.g. animals) from inanimate objects (e.g., vehicles) has been obtained with a wide range of experimental paradigms. In one of these tasks, a selection of objects from two contrasting categories is placed simultaneously before the infant and the sequence in which the infant touches the objects is observed. Infants' understanding of distinctions between the two categories is established when objects that belong to the same category are sequentially touched more frequently than would be expected by chance. Using this object examination task, researchers have found that by 18-20 months of age, infants can distinguish between the animal and vehicle domains, even when vastly dissimilar exemplars belonging to each category are presented (Mandler, Bauer, & McDonough, 1991). Comparable findings have been reported with infants as young as nine to 14 months (Mandler & McDonough,1993; Rakison & Butterworth, 1998a, 1998b). Additional research has also demonstrated that by 24-months of age infants can distinguish animals from other artefacts as well, such as plants, furniture, and kitchen utensils (Mandler, Bauer, & McDonough, 1991). Using a diversity of experimental techniques appropriate for pre-verbal infants, researchers have also demonstrated that infants are capable of distinguishing people from inanimate objects (e.g., Ross, 1980). Spelke, Phillips, and Woodward (1995), for instance, found that seven-month-old infants reasoned differently about people and objects as evidence by their understanding that objects, but not people, require contact to move on their own. Taken together, these results suggest that infants have an understanding of people as different from objects.

The ability to form an Animate-Inanimate (A-I) distinction, to distinguish between living and non-living things, extends beyond simply differentiating animate from inanimate objects, but also entails knowledge of biological properties such as motion. A recent notion that has greatly influenced the field of developmental research proposes that infants distinguish between animates and inanimates on the basis of the motion and mental characteristics of the members of these two categories (Rakison & Poulin-Dubois, 2001). Studies that have examined the use motion cues as a basis for determining animacy have demonstrated that by the end of the first year of life, infants understand that inanimate objects are incapable of moving independently (e.g. Poulin-Dubois, Lepage, & Ferland, 1996; Poulin-Dubois & Shultz, 1988; Phillips & Woodward, 1995). Spelke, Phillips, and Woodward (1995), for instance, found that seven month-old infants reacted differently upon seeing inanimate objects versus people change their motion with or without contact. That is, infants appeared to understand that only people, and not inanimate objects, have the ability to engage in self-propelled movement. Similarly findings were obtained by Poulin-Dubois, Lepage, and Ferland (1996) who examined nine- and 12- month-old infants' reactions when presented with an unfamiliar inanimate object (a remote-controlled robot) and an unfamiliar animate object (a human stranger) which started to move on their own (i.e., without any outside causal force).

Interestingly, infants as young as nine months of age showed an increase in negative affect (e.g., fussing/fretting, crying, clinging to mother) when they witnessed the inanimate object (robot) moving independently. The authors interpreted this finding as evidence that infants as young as nine months understand that inanimate objects are not self-propelled, providing further support for the notion that young infants discriminate between animate and inanimate objects on the basis of motion cues.

Additional research has extended these findings by establishing that between nine and 14 months of age, infants are also capable of appropriately generalizing motion properties to superordinate-level categories of animals and vehicles (e.g. Mandler & McDonough, 1996; Poulin-Dubois, Frenkiel-Fishman, Nayer, & Johnson, 2006). As such, the current dissertation not only sought to explore whether the early ability to generalize motion and psychological properties to animate and inanimate beings is a precursor for the later knowledge of ToM, but also whether there exists developmental continuity between the early understanding of essential properties of living and non-living kinds, such as motion cues, in infancy and a later more developed form of naïve biology. The first set of studies reported here are the first of their kind to examine such longitudinal associations.

The Early Detection of Autism

In the second paper of this dissertation, the interface between naïve psychology and naïve biology was explored in a population of autistic children. Autism is a lifelong neurodevelopmental syndrome characterized by a triad of symptoms: (a) impairment in social interactions, (b) verbal and non-verbal communicative difficulties, and (c) restrictive and stereotypical patterns of behaviour (American Psychiatric Association, 1994). According to the most recent definition in the DSM-IV, the social limitations are typified by an impaired use of non-verbal behaviours to regulate social interaction (e.g. eye contact, facial expression, gestures), a failure to develop age-appropriate peer relationships, and a lack of spontaneous seeking to share enjoyment or interests with others. An absence of social or emotional reciprocity may also be evident. The range of symptoms indicative of communicative dysfunction include a delay or nonexistence of spoken language, a restricted ability to initiate or sustain conversations, stereotyped or repetitive use of language, and difficulties in social imitation or pretend play. Patterns of behaviour are usually characterized by an encompassing preoccupation with stereotyped and restricted interest that is abnormal in intensity or focus, a strict adherence to specific non-functional routines, stereotyped motor movements, and an insistent preoccupation with parts of objects. A delay in social development, language, or in symbolic /imaginative play before the age of three must also be present before a diagnosis of autism can be made. In addition, a specified number of symptoms are required from each category and must have an onset before the age of three.

A great deal of progress has been made over the last twenty years in bringing attention to and promoting awareness of autism. In large part due to a dramatic increase in autism-related research, some of the mystery surrounding this disorder has been resolved. In particular, current conceptualizations of the neuropsychological impairments in autism, such as a deficient ToM, have greatly contributed to our understanding of the disorder. Despite the progress made however, much remains unknown about the developmental progression of the disorder in infancy. In particular, despite clear manifestation of autism-related deficits by 36 months of age, earlier signs of the disorder are not easily identifiable. As such, it is imperative that tasks be developed that allow for the early identification and intervention of very young children with autism, especially in light of research indicating that autistic symptoms may be recognizable early on (e.g. Baron-Cohen et al., 1996; Lord, 1995).

The benefits of early intervention are unquestionable and underscore the need for effective early identification. Parental reports of atypical development during infancy, coupled with the fact that children are seldom diagnosed before 36 months (despite an onset prior to 36 months being a necessary criterion for diagnosis), has prompted a pressing need amongst researchers and practitioners alike for means of accurately detecting autism at a younger age. As such, increasing research is devoted to exploring symptoms of autism that may exist in very young children that would then allow for early identification during routine visits to the child's primary healthcare practitioner. Indeed, recent research suggests that it is possible to recognize symptoms of autism and accurately diagnose autism in toddlers and preschool age children. For example, Lord (1995) found that 88% of children diagnosed with autism at two years of age retained their diagnosis of autism at age three when re-evaluated by a separate, independent clinician. The author also found that an overall clinical judgment of autism at age two was more stable over time than was a diagnosis based on standardized measures of diagnostic criteria obtained at the same age. In a separate study, Stone et al. (1999) examined the diagnostic stability of an autism diagnosis in a sample of 37 children who received an autism spectrum diagnosis at 24 months during an initial evaluation and who returned one year later for a second evaluation conducted by a different clinician. The clinicians were instructed to make diagnoses based on clinical judgments, information available from parental and teacher reports, home and school observation data, and cognitive and developmental test results. The authors found that autism was more stable a diagnosis at two years of age compared to the diagnosis of Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) at the same age. Moreover, when examined one year later, 96% of children originally diagnosed with autism remained on the autism spectrum, while 72% actually retained the specific diagnosis of autism. These findings are consistent with other studies that have found that autism can be diagnosed accurately in children as young as 20 months (Baron-Cohen et al., 1996; Cox et al., 1999). Although it is generally agreed that autism can be diagnosed prior to the DSM's specification of 36 months, and while the urgency of early identification is well-acknowledged in the literature, it is not uncommon for health care professionals to show reluctance in diagnosing autism in very young children (despite evidence of early signs of the disorder, Filipek et al., 1999). Whether due to an initial fear of mislabelling the child or causing undue stress to families, this hesitation to diagnose young children is significantly compounded by the fact that clinicians have available to them few instruments which have been developed specifically to detect autism in young children.

In an attempt to detect the behavioural signs and symptoms of autism at an early age, researchers have comprehensively examined the ToM deficit hypothesis of autism. In 1985, Baron-Cohen, Leslie, & Frith hypothesized that people with autism are specifically impaired in this capacity to reflect upon other people's mental states and that such an impairment can therefore account for their limitations in the realm of social understanding, pretend play, and communication that are considered core features of the disorder. Accordingly, the ToM deficit hypothesis then, posits that "a fault in just one of the many components of the social brain can lead to an inability to understand certain basic aspects of communication" (Hill & Frith, 2004, pg.5). The notion that a ToM deficit is at the root of autism has been advanced by a number of researchers and substantiated by a cornucopia of experimental studies. Following Baron-Cohen et al.'s (1985) suggestion that children with autism have an impairment in meta-representation, that is, in their capacity to represent and predict other's states of mind, a wealth of tests have been developed to explore how the ToM deficit manifests itself in autistic individuals. The most commonly employed ToM test being the false-belief task. Normally developing three- to four-year-old children, as well as children with mild degrees of mental retardation and language impaired children reliably succeed on variations of this task, providing remarkable evidence of understanding representational mental states – of possessing a ToM. In stark contrast, autistic children have been shown to consistently fail false-belief tasks, despite having a higher mental age than their comparison groups (e.g. Baron-Cohen, Leslie, & Frith, 1985; Perner, Frith, Leslie, Leekman, 1989).

Variations of the false-belief task have been administered to groups of autistic subjects with differing IQs, chronological ages, and mental ages and have all yielded a similar pattern of results (see Happé, 1995 for a review). False-belief tasks, however, are not the only tests of ToM on which autistic children have been shown to be impaired. Seeking to better understand autistic children's concept of belief, Sodian & Frith (1992) tested autistic children's ability to manipulate other's beliefs through deception. The authors found that autistic children with a mental age (MA) of four were significantly impaired in their ability to deceive compared to normally developing and mentally retarded children of a similar MA.

The issue of joint attention is also one that has been extensively researched, with consistent findings indicating that autistic children show marked deficits in this area (e.g. Baron-Cohen, Jolliffe, Mortimore, and Robertson, 1997; Carpenter, Pennington, and Rogers, 2002). These findings of impaired ability to use eye gaze for non-verbal communication are supported by a plethora of studies showing that autistic children have difficulties in sharing attention, detecting gaze direction, and orienting to stimuli relative to children with Down syndrome and normally developing children (e.g. Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Mundy, Sigman, & Kasari, 1990). Other ToM tasks that show delays in autistic children include those that assess pretend play and imitative abilities. Consistently, children with autism have been shown to have marked deficits in their production of spontaneous pretend or symbolic play when compared to controls matched on CA or MA (Beeghly, 1998; Lewis & Boucher, 1988). With regards to imitation performance, which has been suggested as a critical component in the development of a ToM, the research is less conclusive concerning autistic children's capabilities. A large body of research does however indicate that older children with autism consistently have imitative limitations, suggesting that an early deficit in imitation does exist (Hobson & Lee, 1999; Smith & Bryson, 1994).

Autistic Children's Understanding of Animacy

The preponderance of research put forth by the ToM account of autism supports the idea that autistic individuals have striking and specific ToM deficits. The link between that of naïve psychology and naïve biology can be further explored by examining whether, in addition to a ToM deficit, autistic children also demonstrate a deficit in naïve biology. This is of particular interest in light a recent proposal that the perception of social information might be related to the processing of biological motion (Castelli, Frith, Happé & Frith, 2002). Rutherford, Pennington, and Rogers (2006) have even argued that the ability to perceive social information is contingent upon the detection of motion properties. This contention has been substantiated by a plethora of studies demonstrating that typically developing children and adults alike can accurately distinguish biological from mechanical motion (Bonda, Petrides, Ostry, & Evans, 1996; Heider & Simmel, 1944; Tremoulet & Feldman, 2000). In the case of autism, it has been suggested that autistic individuals may demonstrate specific deficits in processing perceptual causality or biological motion, which could be linked to ToM deficits (Ray & Schlottmann, 2006).

The possibility that children with autism do not perceive biological motion in the same way as typically developing children has significant clinical implications, notably for the early detection of autism. Rutherford, Pennington, and Rogers (2006) suggested that the ability to form an animate-inanimate (A-I) distinction is a precursor for later social understanding in typical development. If this is indeed the case, the authors also reasoned that the social deficits typical of autism could potentially be linked to an early inability to use motion properties to form an A-I distinction. It stands to reason then that the A-I distinction be another potential precursor for ToM. Furthermore, it is possible that a deficit in the detection of biological motion in autism could be discernable in terms of difficulties to form global categories of animate and inanimate objects. As such, the inability to form an A-I distinction could also be an *early* marker to detect autism-related deficits.

The goal of the second paper of this dissertation therefore was to examine young autistic children's ability to form a global A-I distinction. No study has, as of yet, explored whether typically developing nor atypically developing children can form categories at a higher level of inclusiveness than animals, people, vehicles, and furniture. A categorization task was therefore administered to a group of typically developing 18-month-old infants as well as to a group of young autistic children in order to evaluate their ability to form an animate-inanimate distinction at this domain level.

Certainly, studies on typical child development often contribute to a better understanding of disorders such as autism. In relation to the current thesis, a better understanding of the development of the animacy concept in young typically developing and autistic children, and its link to the acquisition of a ToM can ultimately have a significant impact on the early detection of autism. There currently exists a shortage of screening tools that accurately detect autistic features in young infants, which leads to delays in diagnoses and ultimately poorer outcomes. The benefit derived from longitudinal studies is that the results can be used in the development of screening for individuals at risk for autism. Further, earlier detection is often translated into earlier treatment opportunities. If specific aspects of the proposed putative precursor can be shown to relate to later ToM, these could provide target foci for intervention programmes for individual with autism.

Overall, the current thesis attempts to fill a gap in our existing knowledge of precursors of ToM, advance our understanding about the continuity between these precursors and later ToM and biological knowledge, and potentially contribute to our understanding of ToM deficits in autistic children.

# Chapter 2

# Infants' Concept of Animacy and Later Naïve Biology and Theory of Mind: A Longitudinal Study.

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## Contribution of Authors

This section details the contributions of the first author in the article entitled "Chapter 2: Infants' concept of animacy and later naïve biology and theory of mind: A longitudinal study." The two experiments reported in this paper were both conducted in the Cognitive Development Laboratory in the Centre for Research in Human Development at Concordia University, Montreal.

The experimental methodology and research design for the two preschool studies in Experiment 1 and 2 were designed collaboratively by the first and second authors. The first author created the stimuli used in Theory of Mind battery, devised the administration protocols, orders (i.e., counterbalancing), and coding forms. The infancy study reported in Experiment 2 of this paper was part of the first author's Masters Thesis which was also supervised by the second author and appears in Poulin-Dubois, Frenkiel-Fishman, Nayer, and Johnson (2006).

In preparation for testing, the first author composed recruitment letters, consent forms, and parent questionnaires that were used in each of the studies. Once recruitment letters were mailed, the first author contacted potential participating families by telephone to inquire about their interest in taking part in the studies. A total of 18 participants were tested in the first preschool study and 21 participants were tested in the second preschool study. All the children were tested by the first author who also explained the procedure to the parents, with the exception of a total of six children who were tested by a research assistant. In the latter case, the first author was either present during the testing but stood behind a one-way mirror or reviewed the video tapes of the testing session and coded the data. As well, the first author followed-up with the participating families by writing them a letter thanking them for their participation and informing them of the general results of the studies.

With regards to coding and data analysis, the first author coded all of the children's responses by viewing taped recordings of the testing sessions. A research assistant re-coded the data for reliability purposes and a second assistant conducted inter-rater reliability tests on the coding. The first author then inputted the data into an SPSS worksheet and conducted all subsequent analyses. The first author wrote the abstract, introduction, methods, results, and discussion sections of this paper. The second author provided remarks and revisions on all sections.

Abstract

Two experiments are reported on the relation between the concept of animacy in infancy and children's naïve biology and psychology. In Experiment 1, infants who were administered a generalized imitation task at 16 or 20 months which assessed their ability to generalize target properties to the animate and inanimate domain were followed-up at five years of age and administered a battery of Theory of Mind (ToM) tasks. In Experiment 2, infants who were administered a generalized imitation task at 16 or 20 months which assessed their ability to generalize psychological properties to the appropriate animate category (e.g. people versus animals), were followed-up at six years of age and administered a ToM battery as well as a task designed to measure preschoolers' understanding of the essential properties of living and non-living kinds. Overall, the results of this set of studies are suggestive of a developmental progression between the early understanding of the Animate-Inanimate (A-I) distinction and later knowledge of Theory of Mind such as false belief at the preschool age. As well, developmental continuity between the A-I distinction in infancy and a more advanced kind of naïve biology at preschool age was found, supporting Inagaki and Hatano's (2002) proposal that the A-I distinction in infancy might be a potential precursor to later naïve biology.

Infants' Concept of Animacy and Later Naïve Biology and Theory of Mind:

A Longitudinal Study.

The ability to reflect on the content of one's own and another's mind is a significant cognitive achievement. This achievement, which has been coined 'theory of mind' (ToM) or 'naïve psychology', refers to the ability to infer the full range of mental states that cause action, including beliefs, desires, precepts, thoughts, and other inner experiences to ourselves as well as others (Premack, & Woodruff, 1978; Wellman, 1992). Indeed, without a ToM, social interaction would be virtually impossible.

It is generally accepted that the litmus test for ToM development is the ability to attribute false beliefs – to appreciate that others can possess beliefs about the world that are a misrepresentation of reality. This ability to know and understand others' mental states, as reflected by children's understand of false beliefs, has been found to develop at four to five years of age in normally developing children (Wellman, Cross, & Watson, 2001).

Over the past two decades, children's developing ToM has been the topic of intense research. Much work has examined what children know about a variety of different mental states, the possible theories that can account for the developmental progression of children's understanding of these mental states, as well as the consequences of children's ToM on their social behavior (Flavell, 2004). Along these lines, particular interest has been paid to the question of when, and how, children form mental representations and thus begin to view others as psychological beings (Wellman, 2010).

While the level of ToM development manifested by children's performance on false belief tasks is evident at four or five years, younger children have also been found to demonstrate certain characteristics of an adult-like ToM (Bartsch & Wellman, 1995; Wellman & Liu, 2004, Wellman, Phillips, & Rodriguez, 2000). For instance, by the age of three, children can consider the desires of another and subsequently provide psychological, mentalistic explanations for human behaviour (Colonnesi, Koops, & Meerum, 2008; Wellman & Woolley, 1990). Furthermore, by the time children reach their second birthday, their ability to refer to internal states is already evident in their vocabulary, which includes desire terms such as 'want' (Wellman & Bartsch, 1994). Thus, it is evident that early on, children are readily engaging in desire-based reasoning when interpreting other people's behaviors (Sodian, 2009; Poulin-Dubois, Brooker, & Chow, 2009).

Between 12 and 18 months, infants also demonstrate a number of behaviors that seemingly indicate a "beginning awareness of intentionality" (Flavell, 2004, p.280). In a recent study, 18-month-olds were able to consider the beliefs of an adult when helping the adult achieve a goal, suggesting an early understanding of other's behavior as intentional and goal-directed (Buttelmann, Carpenter, & Tomasello, 2009). Infants' ability to interpret gestures such as pointing and looking at objects as goal-directed has also been demonstrated in several studies (e.g., Phillips, Wellman & Spelke, 2002; Sodian & Thoermer, 2004). As well, between 12 and 15 months, infants classified as high in their understanding of others' intentions have been found to produce a greater proportion of declarative pointing gestures than infants with less understanding of other's intentions (Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004). Taken together, recent research seems to indicate that infants are proficient at reasoning reason about goals and intentions shortly after their first birthday.

The predominant view that children's ability to reason about beliefs, and in particular false beliefs, is not apparent until preschool age has been challenged by a number of recent studies demonstrating that even young infants have some understanding of false beliefs. Southgate, Senju, and Csibra (2007), for instance, conducted a study in which they replaced the classic false-belief test with a nonverbal version and measured 25-month-old infants' anticipatory looking with the use of an eyetracker. The infants were presented with movies depicting an actor seeing a toy being hidden. In the test trial, the children watched as the toy was removed from its original location and hidden in a new location, unbeknownst to the actor. Recordings of the infants' anticipatory looking behaviour indicated that infants reliably anticipated where the actor would look for the toy based on the actor's false belief of the toy's hidden location. Additional studies have supplemented these findings and lent credence to the notion that infants between 13 and 18 months are capable of considering another's false beliefs when predicting that person's behaviour (Buttelmann et. al., 2009; Onishi & Baillargeon, 2005; Song, Onishi, Baillargeon, and Fisher, 2008).

Early manifestations of ToM is also evident in infants' understanding that a person's action goals are influenced by perception. For instance, Luo and Johnson (2009) found that six month-old infants considered what a person could see when interpreting the person's actions toward an object, such as reaching or grasping the object. Using a diversity of experimental paradigms, researchers have found that by the time infants reach their first birthday, they have a rudimentary understanding of the link between a person's visual perception and their subsequent action goals (e.g. Chow, Poulin-Dubois, & Lewis, 2008; Dunphy-Lelii & Wellman, 2004). Taken together, the research to date seems to indicate that by the time children reach the end of their first year of life, they are already conceptualizing people as mental agents and are displaying behaviors suggestive of this budding understanding of others as intentional agents.

The transition from an initial understanding of mental states during the infant and toddler years to a more encompassing, representational ToM at the preschool age has garnered growing interest in the field of cognitive developmental psychology. In fact, recent years have witnessed an upsurge of research on the origins of ToM development and numerous theorists have begun to consider putative precursors of ToM in infancy.

Several accounts of ToM development posit that the emergence of joint attention (Tomasello, 1995), understanding the intentions of others (Meltzoff, 1995), pretence (Leslie, 1987, 1994), and imitation (Rogers & Pennington, 1991) abilities in infancy are linked to later ToM ability. Despite a profusion of literature suggesting that the aforementioned proficiencies during the first years of life constitute infant abilities that are developmental "precursors" to a ToM, much less direct empirical evidence has been provided to support these claims. Surprisingly, there is a relative dearth of longitudinal studies that have addressed the link between ToM precursors and children's later ToM abilities.

In 1993, Taylor, Cartwright, and Carlson reported that children who readily described the presence of an imaginary friend in their lives had an easier time becoming involved in fantasy and were more likely to engage in fantasy play of their own accord than did children who did not possess an imaginary friend. Such findings, along with the earlier suggestion that knowledge of the difference between appearance and reality is a component of the broader ability to reflect upon the content of one's own and another's mind (Flavell, Green, and Flavell, 1986), prompted researchers to examine the possibility of a link between pretence and ToM development. Subsequently, Youngblade and Dunn (1995) conducted a longitudinal study in which they found that infants who engaged in more pretend play at 33 months performed better on false belief tasks and had a better understanding of other people's beliefs and feelings at 40 months of age. The authors concluded that early social pretence denoted a developmental landmark in children's later acquisition of ToM abilities, such as social understanding. Youngblade and Dunn's research represented one of the first studies to establish continuity between infants' social-cognitive abilities and later achievements in preschool by ascertaining the role of early pretense to the later development of ToM abilities.

Joint attention has also been considered an essential element in the development of a ToM. Carpenter, Nagell & Tomasselo (1998) examined the emergence and developmental progression of five specific social-cognitive skills (including joint engagement, attention following and imitative learning) among 24 month-old infants over the course of six months. The authors found that the age range between nine and 12 months represents a critical window for the development of social cognitive skills in infancy. In one of the first longitudinal studies to assess whether joint attention abilities in infancy predict ToM knowledge in childhood, Charman et al. (2000) collected measures of play, joint attention, and imitation abilities in 20-month-old infants followed by measures of ToM functioning at 44 months. While the authors found that joint attention behaviours (alternating between looking at an adult and an object & looking to an adult in the course of an ambiguous goal detection task) predicted ToM ability at 44 months, neither imitation nor play abilities were longitudinally associated with later ToM ability. Most recently, Colonnesi, Rieffe, Koops, and Perucchini (2008) found that behaviors linked to joint attention (i.e. a soliciting pointing gesture) at 12 and 15 months was predictive of ToM performance at 39 months as measured by the use of psychological explanations for mental states.

A number of other studies conducted over the past few years have proposed that the ability to interpret the intentional actions of others is a developmental precursor to the later development of a ToM**.** Olineck and Poulin-Dubois (2005, 2007), for instance, found continuity between intentional imitation at 14-18 months and internal state language at 32 months and intention understanding at four years, providing preliminarily evidence for the relationship between children's early understanding of intentionality and later ToM knowledge. Likewise, Wellman, Phillips, Dunphy-Lelii, and LaLonde (2004) found that 14-month-olds infants' habituation to human intentional action significantly predicted their later performance on ToM tasks at 51 months of age. Similar findings have been reported in other studies using the habituation task whereby a decrease in attention during the habituation task on human intentional action predicted performance on a battery of theory of mind tasks administered at four years of age (Aschersleben, Hofer, & Jovanovic, 2008; Wellman, Lopez-Duran, LaBounty, & Hamilton, 2008; Yamaguchi, Kuhlmeier, Wynn, & vanMarle, 2009)

The above studies have strengthened the notion that an important developmental relationship exists between particular socio-cognitive skills in infancy and later ToM ability. Although a definite consensus regarding the exact predictive function of these developmental precursors has yet to be reached, what seems evident from the research is that these abilities might well be antecedents to a more advanced understanding of mental states. Nonetheless, there remain large gaps in our knowledge of the putative precursors of ToM in infancy. Certainly, more research is required to elucidate the roots of this naïve psychology during the infancy period.

<u>The Animate-Inanimate distinction as a potential precursor to later ToM</u>

Naïve psychology is but one aspect of children's emerging understanding of the world that surrounds them. Another aspect includes children's naïve biology – their classification and reasoning of biological phenomena. The ability to classify and reason about the natural world, which is often referred to as 'folk biology' or 'naïve biology', has become a prevalent theme in the study of children's conceptual knowledge (Inagaki & Hatano, 2002, Wellman & Gelman, 1992). Indeed, children's understanding of biology has been proposed as another basic conceptual domain to that of naïve psychology (Coley, 1985; Wellman & Gelman, 1992), and a great deal of attention has focused on the nature of children's conceptual knowledge of categories. One line of thought proposes that infants form broad categories of objects prior to developing more specific ones. For instance, infants would have formed a broad, domain-general category of animate beings (humans, animals), which incorporates a superordinate-level category of animals (dogs, cats, birds etc.), which itself includes a basic-level category of dogs. This lower-level category is referred to as a subordinate-level category, and in this instance would consist of different types of dogs (e.g., Poodle, Dalmatian, etc). It is widely accepted that infants possess some understanding of superordinate categories that surpasses knowledge of purely perceptual similarities.

The ability to categorize objects into animate and inanimate domains is considered a major milestone in cognitive development (Gelman & Opfer, 2002; Rakison & Poulin-Dubois, 2001). Furthermore, research has established that by the time children reach five years of age, they have advanced beyond simply differentiating animate from inanimate domains to possessing a conceptual understanding of biological occurrences and are capable of making predictions and offering explanations for such phenomena (Inagaki & Hatano, 2006). For instance, Backscheider, Shatz, & Gelman (1993) found that four-year-old children are capable of differentiating plants and animals from non-living things (e.g. artifacts) when it comes to the potential for regrowth. That is, the children in this study had an understanding that plants and animals could regrow when damaged whereas artifacts do not heal through regrowth but rather, need to be mended by humans.

Children's understanding of the biological distinctions between living (e.g. animals) and non-living kinds (e.g. artifacts) has been explored by a host of researchers examining a wide range of criteria for category inclusiveness. Along these lines, Simons and Keil (1995) reported that preschoolers understand that the insides of animals differ to those of machines. Similarly, in a series of experiments designed to examine whether children understand that animals (and not artifacts) grow in size over time, Rosengren, Gelman, Kalish, and McCormick (1991) presented children aged three to six years with a picture of a baby animal and one of a new artifact, followed by a picture of the same animal that had aged and one of the artifact looking more worn. The children were then asked to identify the animal as an adult, or the artifact that had been used for a long time. The authors found that children as young as three and four years of age comprehend that animals, in contrast to inanimate objects, grow in size over time. More recently, Greif, Kemler-Nelson, Keil and Gutierrez (2006) further explored children's understanding of the distinction between animals and artifacts by examining the questions that 32 preschoolers posed relating to animals versus artifacts. The results showed that children's line of questioning differed for animals than for artifacts. Specifically, children asked questions specific to the functions of artifacts whereas they were more likely to inquire about the biologically relevant characteristics of animals (e.g. eating habits, location). The authors argued that the children's questions revealed a "deep-seated conceptual contrast between animals and artifacts" (p.458).

There is also evidence that by preschool age children have acquired an overarching category of 'living things' that encompasses animals and plants as distinct from non-living things. According to Carey (1985), the conceptualization of a broad category of animates that encompasses animals and plants is critical to the formation of naïve biology. The extensive research of Inagaki and Hatano (2002) led the authors to argue that young children not only differentiate animals and plants from non-living things, but they also have a deeper understanding of characteristics shared by animals and plants and have thus formed a superordinate category of living things. For instance, the authors ascertained that five-year-old children recognize that both plants and animals have a mutual need for water and share characteristics such as growth (Inagaki & Hatano, 2002). Although contradictory findings permeate the literature over children's possession of the concept of "alive", Leddon, Waxman, and Medin (2007) found that when the word 'alive' was substituted with the less ambiguous term 'living thing', children were more likely to attribute life status to plants as well as animals. Leddon and colleague thus argued that children have formed a broad category of animates that includes plants and animals by age six to seven, thereby demonstrating an "early appreciation of a core biological concept that includes plants as well as animate entities" (p.470).

Recent research have supplemented studies on children's conceptualization of 'living things' by providing information regarding the understanding of biological properties other than 'alive', such as motion. A leading notion in the field of developmental research is that infants distinguish between animates and inanimates on the basis of the motion and mental characteristics of the members of these two categories at around the middle of the second year of life (Rakison & Poulin-Dubois, 2001). Indeed, a multitude of studies have demonstrated that preschool aged children can correctly infer appropriate motion to animates (i.e. self-propelled, goal-directed) and inanimates (i.e. movement in response to impact or gravity) (Gelman, 1990; Opfer & Siegler, 2004).

Even young children have an understanding of the animate-inanimate (A-I) distinction. More specifically, a number of studies have suggested that from an early age infants are sensitive to motion cues and that by the end of the first year they have acquired an understanding that inanimate objects are not capable of moving on their own (Poulin-Dubois, Lepage, & Ferland, 1996; Poulin-Dubois & Shultz, 1988; Spelke, Phillips & Woodward, 1995). Beyond a basic understanding that animates and inanimates differ as a function of motion properties, it has been established that infants between nine and 14 months are also capable of correctly generalizing motion properties to superordinate-level categories of animals and vehicles (Mandler & McDonough, 1993, 1996; McDonough & Mandler, 1998; Poulin-Dubois, Frenkiel-Fishman, Nayer, & Johnson, 2006).

Research on the A-I distinction seems to indicate a change in the understanding of animate motion during the second year of life which translates into new ways of understanding and conceptualizing human behavior. The research reviewed thus far inspired us to examine how children's naïve biology interfaces with naïve psychology. Little research has attempted to compare children's understanding across both naïve psychology and naïve biology (Binnie & Williams, 2002). As well, what remains unknown is whether there exists a long-term developmental continuity in ToM development from infancy to childhood. Of particular interest is the link between how children distinguish the physical world from mental phenomena and their more advanced ToM knowledge at preschool age. A second line of interest is whether naïve biology has its roots in an earlier understanding of the differences between animates and inanimates. In light of these questions, the main goal of the present set of studies was to further examine longitudinal associations between potential precursor abilities in infancy and the more developed form of naïve psychology and biology in the preschool years.

In two related experiments, we attempt to examine three questions. First, in light of an earlier proposal that the A-I distinction in infancy is a precursor to the living/nonliving distinction (Inagaki & Hatano, 2002), we were interested in examining whether continuity exists between the A-I distinction in infancy and the knowledge of the concept of 'animacy' at the preschool age. Second, taking into consideration Carey's (1985) early assertion that the domain of naïve biology emerges from that of naïve psychology, we were interested in examining whether the understanding of mental states such as desires, intentions, beliefs during preschool years draws upon an earlier understanding of the biological differences between animates and inanimates. It is important to note that recent arguments challenging Carey's position assert that naïve biology is an independent knowledge system, (e.g. Inagaki & Hatano, 1993). Our primary aim is not to shed light on the debate per se, but to test the possibility that the accomplishment of an A-I distinction in infancy might be linked to later ToM ability. As such, we thought it important to investigate whether infants who are better able to distinguish between animate and inanimate properties will perform better on ToM tasks at preschool age. The proposed study is the first of its kind to examine this link. Lastly, we considered whether ToM abilities and knowledge of the concept of 'animacy' are concurrently related at the preschool age.

In Experiment 1, infants who were administered a generalized imitation task at 16 or 20 months which assessed their ability to generalize target properties to the animate (i.e. animals) vs. inanimate (i.e. vehicle) domain were invited to return to the laboratory at five years of age. During the second testing session, the children were administered a version of Tunmer's (1985) animacy-acceptability task whereby they were presented with 36 sentences and asked to judge whether each sentence was "okay" or "silly". The task consisted of some sentences which were semantically anomalous ones violating the animate-inanimate distinction (e.g. "The pencil *ate* the piece of cake on the table") and others which violated the sentient-nonsentient distinction (e.g. "The tree *wants* the babysitter to fix the toy"). To examine whether children's knowledge of people and mental states is developmentally related to their prior knowledge of categories of living and non-living entities, a battery of four ToM tasks (Slaughter, Dennis, & Pritchard, 2002) was also administered during the follow-up testing session at preschool. The battery included tasks that assess mental constructs such as desires, beliefs, and emotions by telling children stories and asking them to guess what a character knows or prefers based on these stories. In Experiment 2**,** a sample of subjects who had participated in a slightly different generalized imitation task in infancy returned to the laboratory at preschool age and were administered the ToM battery as well as a different task to measure knowledge of the concept of 'animacy' at preschool age. The Animacy task in this second study was designed to assess children's naïve thinking about the essential properties of living and non-living kinds (adapted from Inagaki and Sugiyama, 1988). Children were asked to attribute 12 animate properties to phylogenetically varied animate objects (e.g., person, rabbit) and inanimate objects (e.g., stone, tree). The 12 properties consisted of anatomical/biological properties (e.g. heart, bones, breath) and mental/psychological properties (e.g. feeling, wanting).

## Experiment 1

The goal of the current study was twofold: 1) to examine whether knowledge of the A-I distinction in infancy is linked to later ToM ability and to the knowledge of the concept of 'animacy' at the preschool age, and 2) to examine whether ToM abilities and knowledge of the concept of 'animacy' are concurrently related at the preschool age.

## Method

### Participants

The 18 participants (10 boys and 8 girls; *M* = 63.93 months, *SD* = 1.75, range = 60.92-65.95) included in the sample consisted of a group of preschoolers who had originally participated in a generalized imitation task during infancy (at 16 or 20 months) which assessed their ability to generalize target properties to the animate (i.e. animals) or inanimate (i.e. vehicle) domain. All infants had a minimum 35-week gestation period and none had visual or auditory impairments, as reported by their parents. The participants were French- (*N*=5) or English-(*N*=13) speaking from predominantly middle-class families living in the greater Montréal area. Of the 18 participants, ten had participated in the infancy study at 16 months of age and eight had participated in the infancy study at 20 months of age.

The participants were initially recruited from an existing participant pool, available at the Cognitive Development Laboratory at the Centre for Research in Human Development (CRDH) at Concordia University, or through birth lists provided by the Régie Régionale de la Santé et des Services Sociaux de la Région de Montréal-Centre, with the approval of the Commission d'Accès à l'Information du Québec. For the follow-up study at the preschool age, participants who were included in the final sample of the infancy study (N = 60) were re-contacted. The parents were first sent a letter describing the nature of the study and were then contacted by telephone to inquire about their interest in returning to our laboratory with their children. Of the 60 participants who were mailed recruitment letters, 34 were reached by phone. Among those, 18 agreed to participate and subsequently took part in the study. As a result, the final sample of participants included in the follow-up study at preschool age represented 30% of participants who participated in the infancy study. A sample recruitment letter used in Experiment 1 is provided in Appendix A.

Materials

Infant Task

The stimuli employed for the generalized imitation task consisted of a wall and a staircase built of Lego blocks, a small plastic telephone, and a circular mirror attached to a wooden base. Four small plastic replicas of animals (a tiger, a cow, a horse, and a pig) and of vehicles (a truck, a tractor, a bus, and a motorcycle) were used as test exemplars. Small plastic replicas of people (e.g. man, woman, boy, girl) were used to model the four activities.

Preschool Task

The testing session included three tasks: A Theory of Mind (ToM) battery (Slaughter et al., 2002), an Animacy Acceptability task (adapted from Tunmer, 1985) and the English or French version of the Peabody Picture Vocabulary Test-III (PPVT/EVIP) (Dunn & Dunn, 1997), a standardized measure of verbal intelligence. The ToM battery included five tasks that assess mental constructs such as desires, beliefs, and emotions by telling children stories and asking them to guess what a character knows or prefers based on these stories. The materials employed in the administration of the ToM battery included three plasticized photographs of 5-year-old boys and three of 5-year-old girls, a box of Smarties containing crayons, a plasticized picture of a carrot and a cookie, a plasticized picture of a Barbie doll and a racing car, four plasticized images with the schematic figure of a boy in the center and a different chocolate bar at each corner, and four plasticized images with the schematic figure of a girl in the center and a different chocolate bar at each corner. For the latter two sets of pictures, the images differed with respect to which chocolate bar the schematic figure's eyes were directed at. An additional plasticized image of the different chocolate bars at each corner was also employed with no face in the center. All plasticized images measured 21.6 x 35.6 cm.

The Animacy Acceptability Task consisted of 36 questions: four practice questions, 16 semantically acceptable questions, and 16 semantically anomalous questions. The sentences were generally of similar length and were generated using words deemed to be familiar to children of preschool age. An equal number of acceptable and unacceptable sentences were included in order to control for a possible response bias effect. Further, the sentences were arranged in a quasi-random order such that no more than two sentences from any given category were presented consecutively. Consistent with Tunmer (1985), children were tested on two different types of animate properties (eat, sleep) and two different types of sentient properties (want, know). The 16 acceptable questions consisted of equal numbers of questions involving the animate-inanimate domain (e.g. "The father slept in the chair by the fireplace") and the sentient-nonsentient domain (e.g., "The monkey wants to climb the trees in the zoo). Within each of these categories, half the questions consisted of a person as the agent and half in which the agent was a mammal. The 16 unacceptable sentences contained violations of selectional restrictions on verbs and were divided into two groups – those involving the animate-inanimate selectional restriction (e.g. "The pencil ate the piece of cake on the table") and those involving the sentient-nonsentient selectional restriction (e.g. "The tree wants the babysitter to fix the toy). Within the animate-inanimate category, the agent was always a different artifact (e.g., eraser, fridge). The questions within the sentient-nonsentient domain consisted of an equal number of sentences in which the agent was either a plant (e.g. tulip, tree) or an artifact.

The materials employed to administer the PPVT (or the EVIP) a standardized test of receptive lexical knowledge, consisted of English and French versions of a hard cover test kit containing a series of 204 stimulus words and a response sheet. The 204 stimulus words were arranged in order of increasing difficulty and each word was depicted by one of four black and white line drawings arranged on a page called a PicturePlate. The

PicturePlate always consisted of four pictures: one picture which represented the item spoken by the experimenter and three distracter pictures.

Procedure

Infant Task

A generalized imitation task was administered at 16 or 20 months of age. The task consisted a baseline phase and a generalization phase. Infants were tested on four activities: two motion activities (e.g., moving up stairs, jumping over a wall) and two sensory activities (looking, listening). Following a baseline phase during which time infants were allowed to explore the objects until they had touched all of them, infants observed the experimenter model two animate-like motions with a small plastic replica of a person (climbing up stairs, jumping over a block) and two sensory activities (looking into a mirror, listening on a phone). In the generalization phase, infants were given the prop (e.g., the stairs) along with an exemplar from the target domain (e.g., an animal) and an exemplar from the other domain (e.g., a vehicle) and had the opportunity to imitate the modelled actions. A different model exemplar (e.g., the man) was used to demonstrate each activity. The test exemplar pair consisted of one vehicle and one animal. The baseline-modelling-generalization sequence was repeated until all four activities were administered. The four activities were presented in a counterbalanced fashion such that each activity was administered equally often as the first, second, third, or fourth trial, with the exception that no two sensory or motion activities preceded each other. The choice of test exemplars for each activity was also counterbalanced across participants to ensure that each exemplar was presented equally often with each prop, as well as with the test exemplars from the contrasting category. Full details of the experimental measures and procedure of the infancy study are provided in Poulin-Dubois et al. (2006), experiment 2.

Preschool Task

The preschoolers and their parent(s) were greeted in a reception room arranged as a playroom. During a brief warm-up period, the experimenter played with the child to enable him/her to become accustomed to both the new environment and the experimenter. During this time, the parent was asked to sign a consent form and to complete a participant questionnaire. The participant questionnaire requested demographic, familial, and medical information and also served as a screening tool to exclude participants who had physical conditions either before or after birth (i.e., born prematurely, vision/hearing problems). Once the child seemed at ease (usually after 10-15 minutes), the parents and their child were accompanied to the testing room and the parent was invited to observe the session through a one-way mirror. The child was instructed to sit in a child-sized yellow chair at a round table in the center of the testing room. The experimenter sat in a small blue chair across from the participant. All testing sessions were recorded . See Appendix B for sample consent forms used in Experiment 1 and 2 of this paper and Appendix C for a sample participant questionnaire.

Each testing session consisted of three tasks which were administered in a counterbalanced order across all participants such that each task appeared equally often in first, second, or third place. The ToM battery (Slaughter et al., 2002) was composed of five tasks: two standard unexpected contents false belief tasks (Gopnik & Astington, 1988), a conflicting emotion task, a conflicting desire task, and a version of the Four Sweets task (Baron-Cohen, 1994). Within the ToM battery, the administration of the tasks was counterbalanced across participants using a partial Latin square. The sole constraint imposed on the counterbalancing procedure was that the two false-belief tasks were always administered consecutively as they were both relevant to the same story and relied on the same materials. According to Slaughter et al., each of the five tasks is designed to assess children's ability to identify two different mental-state perspectives on the same situations. Each task consisted of a short story involving a story character of the same age as the participant. The story character's gender was always matched with the gender of the participant. The pictures of story characters differed for each task in order to allow children to differentiate between the various stories. A sample protocol for the ToM battery is provided in Appendix D.

The Animacy Acceptability task was presented in the form of a game in which the experimenter held a male or female puppet (matched for the child's gender). The child was told that the puppet would produce some sentences and that the child was to judge whether each sentence was 'okay' or 'silly'. Four practice questions were first administered to the child and corrective feedback was provided in the case of an incorrect response. All four practice questions were semantically anomalous sentences which contained violations that differed from the test questions (e.g. "The ballerina drank the dream"). Following the practice questions, the experimenter administered all 36 test sentences. No feedback was provided for the test questions. However, for sentences on which the children answered 'silly', they were asked to provide explanations for their responses (e.g., "Why is it silly?") up to a maximum of eight questions. A sample protocol for the animacy-acceptability task is provided in Appendix E.

Children were also administered the PPVT. Since language ability has been found to be a strong predictor of ToM performance both concurrently (Jenkins & Astington, 1996), and longitudinally (Astington & Jenkins, 1999), it seemed important to obtain an indicator of preschool verbal ability. The PPVT is a standard measure of receptive vocabulary which has been employed in a number of studies examining the relationship between children's language ability and tasks measuring social competence (e.g., Longoria, Page, Hubbs-Tait, & Kennison, 2009; Olineck & Poulin-Dubois, 2007). Including the PPVT in the battery of tasks therefore allowed for the assessment of, and control for, preschool verbal IQ. The PPVT was administered by showing the child a set of four pictures and asking the child to point to the picture that best represents the word given by the experimenter. Given that the testing time for this task can be quite lengthy depending on the child's vocabulary level, the child was offered a small gift (stickers) intermittently in order to encourage him/her to continue. Upon completion of the study, a small toy and a certificate of merit for contribution to science was given to the children for their participation.

Coding and Scoring

Infant Task

Infants' responses were coded for performance of the target actions with the animal and vehicle test exemplars in the baseline and generalization phases. A response was deemed successful when infants performed an explicit imitation of the modelled activity. The dependent variable was the first object chosen to enact an activity (maximum score = 4). If a participant used both test exemplars to imitate an activity, the first exemplar chosen was considered. For full details of the scoring criteria, please refer to Poulin-Dubois et al. (2006), experiment 2.

Preschool Task

Children's responses on the ToM battery were scored on a pass/fail basis. In order to successfully pass any given task, correct responses were required on all control and test questions. A total ToM score was obtained by summing children's pass/fail scores on the individual ToM tasks (e.g., Self belief, Other belief, Emotion, Desire, Four Sweets), with scores ranging from zero to five. According to Slaughter et al.'s coding procedure, a total ToM score was computed to reveal the general, multifaceted understanding of mental states that children possess. See Appendix F for a sample coding form for the ToM battery.

Children's responses on the Animacy Acceptability task were coded as correct or incorrect. A total score was computed by summing children's correct responses on the 32 test questions. As well, a difference score was computed by subtracting the number of correct responses on the unacceptable animate-inanimate questions from the number of correct responses on the unacceptable sentient-nonsentient questions, with scores ranging from negative eight to plus eight. Because Tunmer's (1985) results revealed a developmental progression in children's understanding of animate versus sentient properties, with the acquisition of the sentient-nonsentient distinction occurring later in development than the animate-inanimate distinction, it was posited that a difference score would be a stricter measure of children's understanding of animacy at preschool age. Higher scores on this difference score measure were taken as an indication of a more developed understanding of the concept of animacy. See Appendix G for a sample coding form for the animacy-acceptability task.

Inter-coder Agreement

Infant Task

The data set was coded by the primary researcher. 20% of the infants were coded a second time by a second, independent, researcher. A percentage agreement was calculated between the two coders' ratings of infants' first-choice responses which served as a measure of intercoder reliability. The average intercoder reliability for the 16-month-old age group was assessed at 94% and 98% for the 20-month-old age group.

Preschool Task

The primary researcher coded all the data. Twenty percent of the data set was further coded by a second, independent coder. Average percentage of intercoder agreement for the ToM battery was 100%. For the Animacy Acceptability task, percentage of intercoder agreement on the total amount of correct responses was also 100%.

## Results and Discussion

Results for the individual tasks are presented first. The results are then divided into three parts, two of which examine longitudinal links between infant measures of categorization ability and preschool measures of ToM and animacy. A third set of results examines the concurrent link between ToM and animacy knowledge at preschool age.

Infant Task

A score of one was assigned for each successfully imitated target activity whereas a score of zero indicated that no activity was imitated. As such, the maximum possible score obtainable on motion trials was two, and likewise on the sensory trials. Group patterns were examined by means of a repeated measures ANOVA with activity (motion, sensory), trial (baseline, generalization), and exemplar (vehicle, animal) as the within-subjects factors. The between-subjects factor was age (16 months, 20 months). The dependent measure consisted of the frequency of target events performed.

The results showed a main effect of trial with infants performing significantly more target actions from baseline ($M$ = 10%) to generalization ($M$ = 41%), $F$ (1, 58) = 91.16, $p < .001$. An interaction between trial and age was also found, $F$ (1, 58) = 6.66, $p$ =.01, $n^2p$ = .11. Follow-up comparisons with Bonferroni adjustments revealed that the 20-month-old group performed significantly more target activities ($M$ = 50%) than the 16-month-old group ($M$ = 32%, $p$ <.01) at generalization, though not at baseline (20 months $M$ = 11%, 16 months $M$ = 10%). Infants also enacted more target activities with the animal ($M$ = 37%) than the vehicle ($M$ = 15%), as evidence by a significant main effect of exemplar, $F$ (1, 58) = 16.94, $p < .001$, $n^2p$ =.23. Furthermore, a trial by exemplar interaction indicated that infants chose the animal ($M$ = 61%) more often than the vehicle ($M$ = 22%) to perform the target activities during the generalization but not the baseline (animal: $M$ = 13%, vehicle: $M$ = 8%) phase, $F$ (1, 58) = 16.04, $p < .001$. As well, an interaction between exemplar and activity indicated that infants chose the animal equally often to enact the motion ($M$ = 35%) and sensory (M = 38%) activities, but preferred the vehicle to perform the motion ($M$ = 21%) over the sensory ($M$ = 9%) activities, $F$ (1, 58) = 4.20, $p$ = .04, as illustrated in Figure 1. Lastly, a main effect of age revealed that 20-month-old infants performed significantly more target activities ($M$ = 30%) than the 16-month-old infants ($M$ = 21%), $F$ (1, 58) = 6.18, $p$ = .02.

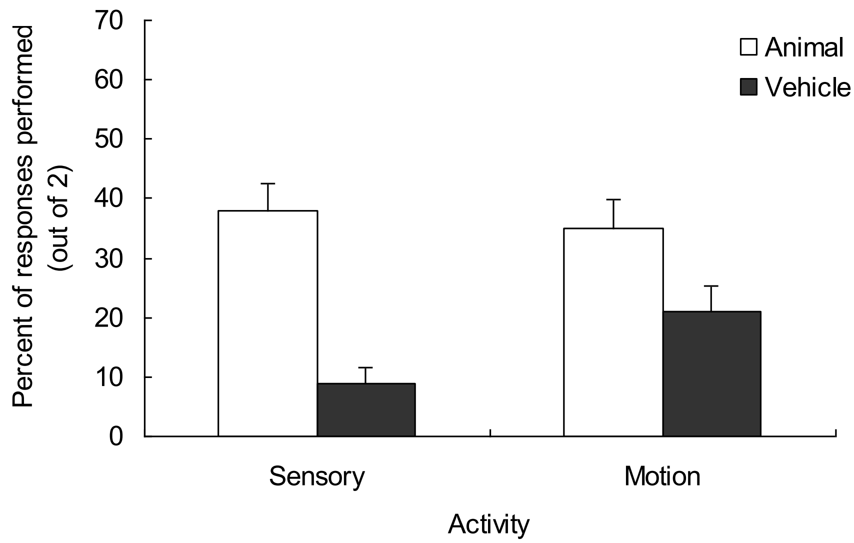


*Figure 1.* Percentage of sensory and motion events performed (+SE) with the animal and vehicle exemplars during the baseline and generalization phase of the infant imitation task in Experiment 1.

Preschool Task

Peabody Picture Vocabulary Test, 3rd edition (PPVT/EVIP-III)

Children's language proficiency was assessed by the PPVT/EVIP-III. Three children did not complete the PPVT. Among the English-speaking children, there was no significant difference in male ($M$ = 108.75, $SD$ = 16.48) versus female children's ($M$ = 117.67, $SD$ = 13.32) performance on the PPVT, $t(9)$ = .83, $p$ = .63, $d$ = -.60. French-speaking male ($M$ = 108.00) and female ($M$ = 117.00, $SD$ = 20.52) children also performed similarly on the PPVT, $t(2)$ = .38, $p$ = .74. As an overall group, there was no significant difference in French-speaking ($M$ = 114.75, $SD$ = 17.35) and English-speaking ($M$=111.18, $SD$ = 15.59) children's performance on the PPVT, $t(13)$ = .38, $p$ = .71, $d$ = .22. As a result, English- and French-speaking children were combined in subsequent analyses.

Theory of Mind and Animacy measures at 64 months

Children's total ToM scores, which were computed by adding together the scores on the Self Belief, Other Belief, Emotion, Desire and Four Sweets tasks, ranged from 0 to 5 ($M$ = 3.06, $SD$ = 1.66), indicating their understanding of mental states. Children's performance on our ToM battery was somewhat higher than that of Slaughter et al.'s (2002) 65-month-old participants who had a mean score of 2.81 ($SD$ = *1.13*) on their ToM scale. We conducted a reliability analysis on children's performance of the five tasks, which revealed a Cronbach's alpha of .71. On this measure, our finding was comparable to Slaughter et. al's reliability value of .51, indicating reasonable internal reliability on a scale of five items.

Children's performance on the Animacy-Acceptability task was coded for correct judgments on each set of 16 a) acceptable psychological ($M$ = 6.44, $SD$ = 1.63), b) acceptable biological ($M$ = 5.13, $SD$ = 1.78), c) unacceptable psychological ($M$ = 7.13, $SD$ = 1.31), and d) unacceptable biological sentences ($M$ = 6.63, $SD$ = 1.54). Children's performance on this task was compared to that of Tunmer's (1985) sample of five-year-old participants. Since mean values were not published in Tunmer's article, we present approximate values derived from Tunmer's graph (p. 995): a) acceptable psychological (Tunmer = 83%, Current study = 40%), b) acceptable biological (Tunmer = 83%, Current study = 32%), c) unacceptable psychological (Tunmer = 71%, Current study = 45%), and d) unacceptable biological sentences (Tunmer = 94%, Current study = 41%). The data suggest that the sample of children in this study did not perform as well on our Animacy task as those in Tunmer's study. It may be that the adapted version of Tunmer's task employed in this study did not tap into children's understanding of animacy as well as the original version, thereby accounting for the overall lower performance on our task. Another possibility may be that the children were simply focusing on an unusual string of words in the sentences – a grammatical anomaly - rather than focusing on the semantic anomaly of the sentences. This seems unlikely however in light of the fact that some variability nonetheless exists across performance on the different categories of questions in our study. Moreover, the difference in performance on the unacceptable psychological sentences (71%) versus the unacceptable biological sentences (94%) in Tunmer's study seems to indicate that children are not simply focusing on the grammatical anomalies of the sentences but rather, are indeed being attentive to the acceptability of the sentences. Furthermore, consistent with Tunmer's sample of five-year-old participants, it seems that performance on our Animacy task was also relatively consistent across the different categories of questions. Table 1 shows the mean scores on the ToM and Animacy preschool measures administered in Experiment 1.

Longitudinal Analyses

The relationship between the understanding of the A-I distinction in infancy and ToM at preschool age

The small number of participants who returned at Time 2 to participate in the preschool study prevented us from considering the two age groups in the induction study separately when reporting the results of the longitudinal analyses. Since examining the difference in performance between the 16- and 20-month old infants at Time 2 was not possible, we therefore report here only the results of the induction study collapsed over age.

The objective of the first set of analyses was to determine whether the ability to categorize objects into animate and inanimate domains, an ability that develops during the second year of life, is a predictor of ToM ability at preschool age. This was done by generating a correlation between the total amount of times (maximum score out of four) infants chose the animal over the vehicle at 16 or 20 months during the generalization trial and ToM ability at 64 months, as measured by a total ToM score (maximum score out of five). Children's performance on the infancy task, as measured by a total score, did not predict ToM ability at preschool age, $r(18)=.31$, $p=.21$.

A second analysis was conducted to further examine this longitudinal relationship. A difference score was computed from the inductive generalization task by

Table 1

*Scores for all experimental variables administered to preschoolers in Experiment 1*

| | *N* | Mean | SD |
|---|---|---|---|
| False Belief (out of 2) | 18 | 1.39 | .85 |
| Emotion | 18 | .61 | .50 |
| Desires | 18 | .39 | .50 |
| Four Sweets | 18 | .67 | .49 |
| Total ToM Score | 18 | 3.06 | 1.66 |
| Total Acceptable Psychological | 16 | 6.44 | 1.63 |
| Total Acceptable Biological | 16 | 5.13 | 1.78 |
| Total Unacceptable Psychological | 16 | 7.13 | 1.31 |
| Total Unacceptable Biological | 16 | 6.63 | 1.54 |

subtracting the number of times the infant chose the animal to model the target activity at baseline from the number of times the infant chose the animal to do so at generalization. It is important to recall that infants were presented with both an animal and a vehicle exemplar at generalization. A higher differencescore would therefore indicate that infants chose the animals more often than the vehicles at generalization (while taking into account their baseline performance), suggesting that they correctly understood that animals were more appropriate than vehicles to perform the target activities. To examine whether performance on the infancy task using this difference score predicted performance on the preschool ToM task, a Pearson correlation was conducted between the difference score on the induction task and the total ToM score. No statistical significant correlation was found $r(18)=.12$, $p=.65$. Infants' performance on the induction task, as measured by both the total score ($r(11)=.02$, $p=.95$) and the difference score ($r(11)=-.08$, $p=.79$) measures also failed to correlate with ToM ability at preschool age when the PPVT was partialed out (3 children could not be included in these latter analyses due to an inability to complete the PPVT).

Seeing as false belief understanding has traditionally been viewed as the cornerstone of ToM development (e.g. Wellman, Cross, & Watson, 2001; Wimmer & Perner, 1983), an analysis examining the relationship between performance on the infancy task and false belief understanding at preschool age was conducted. Success on the false-belief task was defined conservatively as a perfect score out of two. A point-biserial correlation between the total score on the infancy task and scores on the false belief task reached marginal significance $r_{pb}(18)=.41$, $p=.09$, though the relationship between the difference score on the infancy task and knowledge of false belief did not reach significance $r_{pb}(18)=.32$, $p=.19$.

A final analysis was conducted to explore whether children who passed the false-belief task had a better understanding of the animate-inanimate distinction at infancy than those who failed the false-belief task. Children who passed the false-belief task (N=61%) tended to choose the animal over the vehicle at generalization more often than those who failed the false-belief task (N=39%), although this just reached marginal statistical significance $t(16)=1.81$, $p=.09$.

The relationship between the understanding of the A-I distinction in infancy and knowledge of animacy at preschool age

In the second set of analyses, the goal was to examine whether there exists a longitudinal relationship between knowledge of the animate-inanimate distinction at 16 or 20 months and a more developed understanding of animacy at 64 months. Infants' performance on the inductive generalization task, as measured both by a total score and by a difference score, failed to correlate with performance on the animacy acceptability task, as measured by children's total number of correct responses out of 32 (total score: $r(16)=.22$, $p=.41$; difference score: $r(16)=.16$, $p=.56$). Infants' performance on the induction task, as measured by both the total score ($r(11)=.11$, $p=.71$ ) and the difference score ($r(11)=.22$, $p=.47$) measures also failed to correlate with animacy knowledge at preschool age when the PPVT was partialed out (5 children could not be included in these latter analyses due to an inability to complete the AA task and/or the PPVT).

Infant's performance on the induction task was also correlated with performance on the animacy-acceptability task as measured by a difference in the number of correct responses on the unacceptable animate-inanimate questions and the number of correct responses on the unacceptable sentient-nonsentient questions. Using the difference score on the infancy task as a measure of infant's understanding of the animate-inanimate distinction did not produce any significant findings, $r(16)=.31$, $p=.24$. However, using a total score (the total amount of times out of four that infants chose the animal over the vehicle during the generalization trial) on the infancy task to generate the correlation indicated that infants' choice of the animal at generalization strongly predicted performance on the animacy acceptability task as measured by the difference score, $r(16)=.55$, $p=.03$. It was then examined whether the significant correlation could be accounted for by a more general association between knowledge of animacy and later verbal language. The relationship remained when PPVT scores were partialed out, although this missed significance $r(11)=.50$, $p=.09$.

Concurrent Analyses

The concurrent relationship between ToM and concept of animacy at preschool age

In the third set of analyses, we examined whether ToM ability and knowledge of animacy are concurrently related at the preschool age. There was a significant correlation between children's performance on the AA task, as measured by a total score, and their performance on the ToM task, $r(16)=.59$, $p=.02$, though this did not remain significant once the PPVT was partialed out, $r(11)=.28$, $p=.36$. Using a difference score on the AA task as indicative of animacy knowledge revealed a trend for the two measures to be related, $r(16)=.47$, $p=.07$, though this trend did not remain once the PPVT was partialled out $r(11)=.13$, $p$=68. The Pearson correlations computed between all dependent variables in Experiment 1 and the partial correlations which factored out verbal language ability, are presented in Table 2.

Table 2

*Intercorrelations between children's performance on the infant generalized imitation task and performance on preschool theory of mind and animacy tasks in Experiment 1. Partial correlations, which factored out verbal language ability (PPVT scores), are presented in parentheses.*

| | IT-TOTAL | IT-DIFF | TOM TOTAL | FB | AT-TOTAL | AT-DIFF |
|---|---|---|---|---|---|---|
| Induction Task: Total Score (IT-TOTAL) | 1.00 | .90** (.91) | .31 (.02) | .41 | .22 (.11) | .55* (.50) |
| Induction Task: Difference Score (IT-DIFF) | | 1.00 | .12 (-.08) | .32 | .16 (.22) | .31 (.33) |
| Total ToM Score (TOM TOTAL) | | | 1.00 | .80** | .59* (-.28) | .47 (.13) |
| False Belief Task (FB) | | | | 1.00 | .54* | .45 |
| Animacy Task: Total Correct Responses (AT-TOTAL) | | | | | 1.00 | .37 (.04) |
| Animacy Task: Difference Score (AT-DIFF) | | | | | | 1.00 |

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

## Experiment 2

The current study aimed to replicate Experiment 1 using a sample of subjects who had participated in a slightly different generalized imitation task in infancy. As well, in light of Inagaki and Hatano's (1992) assertion that the understanding of the distinction between living and non-living things is essential to the later development of biological knowledge, we employed a different task to measure knowledge of the concept of 'animacy' at preschool age, adapted from Inagaki and Sugiyama (1988). Of particular interest was the question of whether children's ability to generalize motion and psychological properties in infancy might predict their later ability to attribute physiological and psychological properties at preschool age. The ToM task of Experiment 1 and the PPVT were also administered. The Animacy task in the current study was designed to assess children's naïve thinking about the essential properties of living and non-living kinds. The goal of the current study was twofold: 1) to examine whether the ability to generalize motion and sensory activities across a broad animate domain in infancy is linked to later ToM ability and to children's naïve thinking about the essential properties of living and non-living kinds at the preschool age, and 2) to examine whether ToM abilities and children's naïve thinking of concepts of living kinds are concurrently related at the preschool age.

### Method

#### Participants

The 21 participants (12 boys and 9 girls; *M* = 72.07 months, *SD* = .97, range = 70.72-74.30) included in the sample consisted of a group of preschoolers who had originally participated in a generalized imitation task during infancy (at 16 or 20 months) which assessed their ability to generalize motion (e.g. moving up stairs) and sensory (e.g. looking in a mirror) properties to animals and people. The inclusion criteria consisted of a minimum 35-week gestation period and no visual or auditory impairments. The participants were French- (*N*=6) or English-(*N*=15) speaking from predominantly middle-class families living in the greater Montréal area. Of the 21 participants, nine had participated in the infancy study at 16 months of age and 12 had participated in the infancy study at 20 months of age.

The recruitment of participants in this study was identical to that of Experiment 1. For the follow-up study at the preschool age, participants who were included in the final sample of the infancy study (N = 48) were re-contacted. As in Experiment 1, the parents were first sent a letter describing the nature of the study and were then contacted by telephone to inquire about their interest in returning to our laboratory with their children. Of the 48 participants who were mailed recruitment letters, 21 were reached by phone and agreed to participate. As a result, the final sample of participants included in the follow-up study at preschool age represented 44% of participants who participated in the infancy study. A sample recruitment letter for Experiment 2 is provided in Appendix H.

Materials

Infant Task

The materials and procedure of the infancy study were identical to the infancy study of Experiment 1, with the exception being that a monkey doll was used as the model exemplar and miniature replicas of people and animals served as test exemplars.

Preschool Task

As in Experiment 1, the testing session included three tasks: A Theory of Mind (ToM) battery (Slaughter et al., 2002), an Animacy task (adapted from Inagaki and Sugiyama, 1988) and the Peabody Picture Vocabulary Test (PPVT) or EVIP test. The materials and the administration of the ToM battery and the PPVT were identical to that of Experiment 1.

The Animacy task was specifically designed to measure preschoolers' naïve understanding of the distinction between psychological and biological properties. The task consisted of 12 questions pertaining to each of eight phylogenetically different objects (person, rabbit, pigeon, fish, grasshopper, tulip, tree, stone) making a total of 96 questions asked. The 12 properties assessed consisted of four unobservable anatomical/biological properties (heart, bones, breath, growth), five unobservable mental/psychological properties (thinking, feeling happiness, feeling pain (sensation), wanting, knowing), and three observable properties (eyes, movement, speech). All 12 properties were asked about a specific target object (e.g. the person) before the experimenter proceeded to another object. The specific order in which the properties were assessed was fixed within each of the set of 12 questions and adhered to the following order: eye, bones, breath, growth, sensation, movement, thinking, wanting, knowing, feeling, speaking, and heart. However, the order in which the eight target objects were administered was counterbalanced across subjects.

<u>Procedure</u>

<u>Infant Task</u>

The administration of the generalized imitation task was identical to that of Experiment 1, with the exception of the model and test exemplars. Full details of the experimental measures and procedure of the infancy study are provided in Experiment 3 of Poulin-Dubois et al. (2006).

Preschool Task

The procedure and design were the same as in Experiment 1, as was the counterbalanced order in which the tasks were administered. Each testing session therefore consisted of three tasks: The ToM battery, Animacy task, and the PPVT/EVIP. The Animacy task was presented in the form of a game whereby the experimenter asked the child questions and the child was required to answer yes or no to those questions (e.g. “Does a tulip have a heart?”). No feedback was provided for the questions. Given the length of the task, children were given stickers randomly throughout the task in order to motivate them.

Coding and Scoring

Infant Task

As in Experiment 1, infants’ responses were coded for performance of the target actions with the animal and person test exemplars for the baseline and generalization phases.

Preschool Task

Children’s responses on the ToM battery and the PPVT were scored according to the protocol outlined in Experiment 1. Children’s responses on the Animacy task were coded as correct or incorrect. Percentages of over-attribution and under-attribution errors were calculated out of the total responses of the objects having the property, or those not having it. The *over-attribution* errors for the *anatomical/physiological* properties were made my attributing: bones, breath, growth and heart to the stone; bones to the grasshopper; bones and heart to plants. The over-attribution errors for the *mental/psychological* properties were made my attributing: thinking and feeling pain to the fish, grasshopper, plants, and the stone; feeling happy to all the objects apart from the person; wanting and knowing to the fish, grasshopper, plants, and the stone. The over-attribution errors for the *observable* properties were made my attributing: eyes and movement to the stone and plants; speech to all the objects except for a person. The *under-attribution* errors for the anatomical, mental, and observable properties consisted of 'NO' responses to the remaining objects. A sample administration and coding protocol for the Animacy task is provided in Appendix I.

Inter-coder Agreement

Infant Task

The data from the infancy study was coded by the primary researcher. A subset of infants (20%) was coded by a second, independent, researcher. A percentage agreement was calculated between the two coders' ratings of infants' first-choice responses which served as a measure of intercoder reliability. The average intercoder reliability for both the 16- and 20-month-old age groups was assessed at 96%.

Preschool Task

The primary researcher coded all the data. Twenty percent of the data set was further coded by a second, independent coder. Percentage of intercoder agreement for the both the ToM battery and the Animacy task was 100%.

## Results and Discussion

Results for the individual tasks are presented first. The results are then divided into three parts, two of which examine longitudinal links between infant measures of categorization ability and preschool measures of ToM and knowledge of essential properties of living and non-living kinds. A third set of results examines the concurrent link between ToM and knowledge of essential properties of living and non-living kinds at the preschool age.

Infant Task

Consistent with Experiment 1, infants received a score of 1 for each target activity that was successfully imitated, and a score of 0 if no activity was imitated. A repeated measures ANOVA was conducted with activity (motion, sensory), trial (baseline, generalization), and exemplar (person, animal) as the within-subjects factors. Age (16 months, 20 months) served as the between-subject factor. The frequency of target events performed served as the dependent measure.

A main effect of trial indicated that infants performed more target activities during the generalization (M = 57%) than during the baseline phase (M = 14%), F (1, 46) = 124.92, $p < .001$, $n^2p = .73$. This main effect of trial was qualified by an interaction with age group, $F(1, 46) = 7.43$, $p < .01$, $n^2p = .14$. Follow-up comparisons with Bonferroni adjustments revealed that the 20-month-old group performed significantly more activities ($M = 73\%$) than did 16-month-old infants ($M = 41\%$) during the generalization phase ($p < .001$), but not during the baseline phase (16 months: $M= 8\%$; 20 months: $M= 20\%$, $p = .08$). Further, an interaction between activity and age was discovered, $F(1, 46) = 4.26$, $p = .04$, $n^2p = .09$, which was qualified by an interaction between activity, trial, and age, $F(1, 46) = 4.85$, $p = .03$, $n^2p = .10$. More specifically, 20-month-old infants imitated the sensory activities ($M = 81\%$) to a greater extent than did 16-month-old infants ($M = 31\%$) during the generalization phase, $p < .001$. This effect and these interactions were further subsumed under a significant four-way interaction between activity, trial, exemplar, and age, $F(1, 46) = 6.28$, $p = .02$, $n^2p = .12$. Each type of activity was subjected to pairwise comparisons. During the baseline phase of motion trials, 16- and 20-month-old infants chose the person and the animal equally often to perform the activity (16 months: $M = 2\%$, $M = 8\%$, respectively, $p = .30$; 20 months: $M = 15\%$, $M = 6\%$, respectively, $p = .17$). Similarly, during the generalization phase of motion trials, both the 16- and 20-month-old age groups chose the person and animal equally often to perform the target activity (16 months: $M = 31\%$, $M = 19\ \%$, respectively, $p = .23$; 20 months: $M = 33\%$, $M = 31\%$, respectively, $p = .84$).

A different picture emerged when analyzing children's responses on the sensory activities. During both the baseline and generalization phases of the sensory trials, 16-month-old infants chose the person and animal equally often to imitate these activities (baseline: person $M = 2\%$ animal $M = 4\%$, $p = .69$; generalization: person $M = 13\%$ animal $M = 19\%$, $p = .52$). In contrast, the 20-month-old infants chose the person and animal equally often to imitate the sensory activities only during the baseline phase ($M = 13\%$, $M = 6\%$, respectively, $p = .23$). During generalization, 20-month-old infants imitated the sensory activities with a person ($M = 52\%$) significantly more often than with an animal ($M = 29\%$), suggesting that by this age, infants are reserving sensory properties for people, $p = .02$. The percentage of responses for 16- and 20-month-old infants on motion as well as sensory trials at generalization is illustrated in Figure 2.

Preschool Task

Peabody Picture Vocabulary Test, 3rd edition (PPVT/EVIP-III)

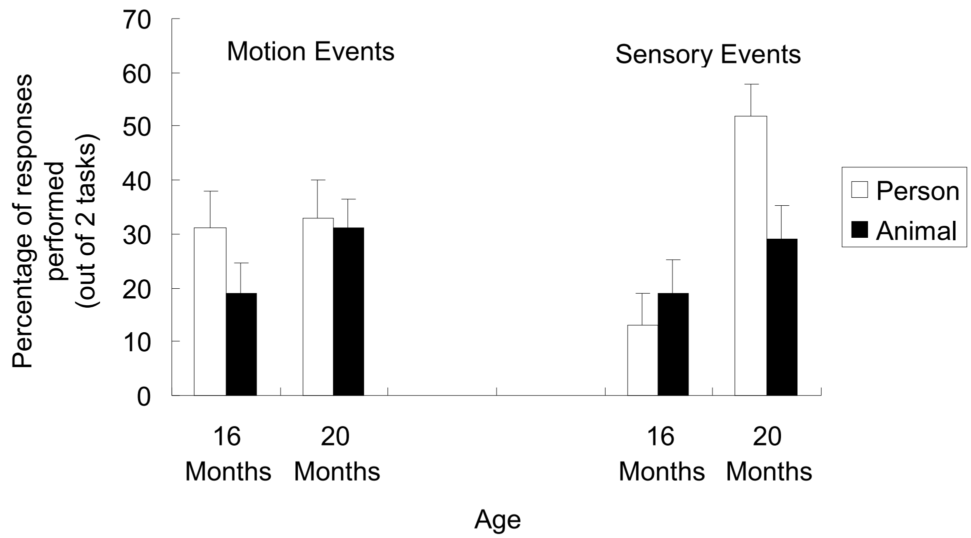


*Figure 2.* Percentage of motion and sensory events performed (+SE) with people and animal exemplars during the generalization phase of the infant imitation task in Experiment 2.

Children's language proficiency was assessed by the PPVT/EVIP-III. Among the English speaking children, there was no significant difference in males's (*M* = 110.25, *SD* = 11.79) versus female children's (*M* = 116.86, *SD* = 18.70) performace on the PPVT, *t*(13) = .83, *p* = .72, *d* = .42. French-speaking male (*M* = 130.50, *SD* = 6.36) and female (*M* = 126.00, *SD* = 19.65) children also performed similarly on the PPVT, *t*(4) = .30, *p* = .47, *d* = .31. As a group, there was a marginal difference in French-speaking (*M*= 127.5, *SD* = 15.66) and English-speaking (*M*=113.33, *SD* = 15.20) children's performance on the PPVT, though this did not reach statistical significance, *t* (19) = 1.91, *p* = .07, *d* =.92. As a result, English and French speaking children were combined in subsequent analyses.

<u>Theory of Mind and Animacy measures at 72 months.</u>

Children's total ToM scores, which were computed by adding together the scores on the Self Belief, Other Belief, Emotion, Desire and Four Sweets tasks, ranged from two to five (*M* = 3.67, *SD* = 1.07), indicating their understanding of mental states. Our sample of children performed better on this ToM battery when compared to Slaughter et al.'s (2002) sample of 65-month-old participants' performance on their ToM scale (*M* = 2 .81, *SD* = 1.13), which is expected in light of the discrepancy in age between the two groups. We conducted a reliability analysis on children's performance of the five tasks, which revealed a Cronbach's alpha of .65. This finding was comparable to Slaughter et. al's reliability value of .51, indicating good internal reliability on a scale of five items. The mean scores on the ToM battery of Experiment 2 are presented in Table 3.

Children's performance on the (Animacy) task was coded for percentage of over- and under-attribution errors of anatomical (over: 13.8%, under: 26.1%), mental (over: 34%, under: 19.8%), and observable (over: 5.1%, under: 4.8%) properties. Children's

Table 3

*The mean scores on the ToM battery administered to preschoolers in Experiment 2.*

| | *N* | Mean | SD |
|---|---|---|---|
| False Belief (out of 2) | 21 | 1.57 | .68 |
| Emotion | 21 | .86 | .36 |
| Desires | 21 | .52 | .51 |
| Four Sweets | 21 | .71 | .46 |
| Total ToM Score | 21 | 3.67 | 1.07 |

performance on the anatomical and mental properties was comparable to that of Inagaki and Sugiyama's (1988) five-year-old participants (anatomical: over: 6.7%, under: 26.1%; mental: over: 48.5%, under: 15.0%). Table 4 shows the percentage of over- and under-attribution errors for the three types of properties.

Longitudinal Analyses

The relationship between the ability to generalize motion and sensory activities across a broad animate domain in infancy and ToM at preschool age

In this second study as well, the small number of returning participants for the preschool study prevented considering the two age groups in the induction study separately. As a result, both age groups were pooled and results are presented as group averages. The objective of this first set of analyses was to determine whether the ability to generalize sensory activities to people rather than animals in infancy predicts ToM ability at preschool age. This was done by generating the correlation between the total amount of times (maximum score out of two) infants chose the person over the animal for the sensory activities at 16 or 20 months and ToM ability at 64 months, as measured by a total ToM score (maximum score out of five). Children's performance on the infancy task, as measured by this total score, did not predict ToM ability at preschool age, $r(21)= -.05$, $p=.83$. Another total score was calculated which reflected children's understandings that motion properties were appropriate to a broad animate domain consisting of both people and animals. This was done by calculating the total amount of times (maximum score out of four) infants chose either the animal or the person for the motion activities. To determine whether the ability to generalize motion activities across a broad animate

Table 4

*The mean percentages of under- and over-attribution errors for each type of property on the animacy task in Experiment 2*

| | Anatomical Properties | | Mental Properties | | Observable Properties | |
|---|---|---|---|---|---|---|
| Age | Under- | Over- | Under- | Over- | Under- | Over- |
| (months) | (483) | (189) | (273) | (567) | (231) | (273) |
| 72.07 | 26.1 | 13.8 | 19.8 | 34.0 | 4.8 | 5.1 |

*Note*. Figures in parentheses reflect total responses.

domain in infancy predicts ToM ability at preschool age, we correlated this latter total score on the infancy task with ToM ability at 64 months, as measured by the total ToM score. Here too, performance on the infancy task did not predict ToM ability at preschool age, $r(21)=-.10, p=.65$.

A second set of analyses was conducted to further examine this longitudinal relationship. In this case, a difference score was obtained from the inductive generalization task as the difference between the number of times the infant chose the person to model the sensory activities at generalization and the number of times the infant chose the person to do so at baseline. Recall that infants were presented with both a person and an animal exemplar at generalization. A higher score on this difference score measure would therefore indicate that infants chose the person more often than the animal at generalization for the sensory activities, while taking into account their baseline performance. This would suggest that infants correctly understood that people were more appropriate than animals to perform the sensory activities. To examine whether performance on the infancy task using this difference score predicted performance on the preschool ToM task, a Pearson correlation was conducted between the difference score on the induction task and the total ToM score. No statistical significant correlation was found $r(21)=.00$, $p=1.00$. Another difference score was calculated to reflect children's understanding that motion properties can be generalized to a broad animate domain, taking into account their baseline performance. In this case, the difference between the amount of times infants chose either the animal or person to perform motion activities at generalization and the amount of times they did so at baseline was calculated. No significant correlation was found between this latter difference score measure and ToM ability at preschool age, *r*(21)= .03, *p*=.90. All four of the measures stated above remained non significant when the PPVT was partialed out.

An analysis examining the relationship between performance on the infancy task and false belief understanding at preschool age, as measured by children's understanding of False-Belief, was conducted. Success on the false-belief task was defined as a perfect score out of two. A point-biserial correlation, due to the presence of one dichotomous variable and one continuous various, was conducted between the total amount of times infants chose the person (out of two) to model the sensory activities in the induction task and scores on the false belief task. This point-biserial correlation was not significant $r_{pb}(21)=.06$, $p=.81$, nor was the relationship between the difference score (as the difference between the number of times the infant chose the person to model the sensory activities at generalization and the number of times the infant chose the person to do so at baseline) on the infancy task and knowledge of false belief $r_{pb}(21)=.00$, $p=1.00$.

Lastly, an analysis was conducted to explore whether children who passed the false-belief task had a better understanding of the animate-inanimate distinction at infancy than those who failed the false-belief task. Children who passed the false-belief task (N=67%) were not more likely to choose the person over the animal at generalization (on sensory trials) than those who failed the false-belief task (N=33%), $t(19)=-2.4$, $p=.81$.

The relationship between the ability to generalize motion and sensory activities across a broad animate domain in infancy and knowledge of animacy at preschool age

In this second set of analyses, we sought to determine whether there exists a longitudinal relationship between knowledge of the animate-inanimate distinction at 16 or 20 months and a more developed understanding of living and non-living kinds at 72 months. Infants' performance on the inductive generalization task as measured by the total amount of times (maximum score out of two) infants chose the person over the animal for the *sensory* activities at 16 or 20 months failed to correlate with performance on the Animacy task, as measured by children's under- and over-attribution errors for both the anatomical (under: $r(21)=.08$, $p=.72$; over: $r(21)=.26$, $p=.26$) and mental (under: $r(21)=-.07$, $p=.76$; over: $r(21)=-.00$, $p=.98$) properties. Using the total amount of times (maximum score out of four) infants chose either the animal or the person for the *motion* activities in the induction task as a measure of infants' knowledge of the broad animate domain also failed to correlate with performance on the Animacy task, as measured by children's under- and over-attribution errors for both the anatomical (under: $r(21)=-.29$, $p=.20$; over: $r(21)=.05$, $p=.82$; ) and mental (under: $r(21)=-.20$, $p=.39$; over: $r(21)=.17$, $p=.46$).

We also ran correlations using difference score measures as reflective of infants' performance on the induction task. For the first analysis of this kind, a difference score was obtained from the inductive generalization task as the difference between the number of times the infant chose the person to model the sensory activities at generalization and the number of times the infant chose the person to do so at baseline. This difference score measure failed to correlate with performance on the Animacy task, as measured by children's under- and over-attribution errors for both the anatomical (under: $r(21)=-.07$, $p= .76$; over: $r(21)=.11$, $p=.63$) and mental (under: $r(21)= -.13$, $p=.57$; over: $r(21)=.00$, $p=.97$) properties. A similar analysis using another difference score measure (the difference between the amount of times infants chose either the animal or person to perform motion activities at generalization and the amount of times they did so at baseline) on the induction task also failed to yield any significant results when correlated with children's under- and over-attribution errors for the anatomical (under: $r(21)= .22$, $p= .35$; over: $r(21)=.01$, $p= .96$) and mental (under: $r(21)= .07$, $p=.76$; over: $r(21)= .04$, $p=.87$) properties.

<u>The concurrent relationship between ToM and knowledge of animacy at preschool age</u>

In this third set of analyses, we examined whether ToM ability and knowledge of living and non-living kinds are concurrently related at the preschool age. Children's performance on the Animacy task, as measured by the proportion of over-attribution errors on the anatomical properties correlated significantly with their performance on the ToM task, $r(21)=-.48$, $p=.03$. This relationship remained significant even after the PPVT was partialed out, $r(18)=-.47$, $p=.04$. However, children's performance on the Animacy task as measured the proportion of under-attribution errors on the anatomical properties as well as by the proportion of over- and under-attribution errors on the mental properties failed to correlate with knowledge of false belief (anatomical: under $r(21)= .01$, $p=.96$; mental: over: $r(21)= .15$, $p=.51$, under: $r(21)=-.36$, $p=.11$). The intercorrelations between performance on the infancy task and knowledge of ToM and animacy at preschool age are presented in Table 5.

Table 5

*Intercorrelations between children's performance on the infant generalized imitation task and performance on the preschool theory of mind and animacy tasks in Experiment 2.*

| | IT: S | IT: M | ID: PS | ID: PM | TTS | FB | A: UA | A: OA | A: UM | A: OM |
|---|---|---|---|---|---|---|---|---|---|---|
| Induction Total Score: Sensory (IT: S) | 1.00 | -.22 | .84** | -.33 | -.05 | .06 | .08 | .26 | -.07 | -.00 |
| Induction Total Score: Motion (IT: M) | | 1.00 | -.29 | .61** | -.10 | .18 | -.29 | .05 | -.20 | .17 |
| Induction Difference Score: Person Sensory (ID: PS) | | | 1.00 | -.27 | .00 | .00 | -.07 | .11 | -.13 | -.00 |
| Induction Difference Score: Person Motion (ID: PM) | | | | 1.00 | .03 | .06 | .22 | .01 | .07 | .04 |
| Total ToM Score (TTS) | | | | | 1.00 | .55** | .01 | -.48* | -.36 | .15 |
| False Belief (FB) | | | | | | 1.00 | -.11 | -.11 | -.29 | .03 |
| Animacy: Under-Attrib. Anatomical (A: UA) | | | | | | | 1.00 | .02 | .65** | -.40 |
| Animacy: Over-Attrib. Anatomical (A: OA) | | | | | | | | 1.00 | .10 | -.10 |
| Animacy: Under-Attrib. Mental (A: UM) | | | | | | | | | 1.00 | -.78** |
| Animacy: Over-Attrib. Mental (A: OM) | | | | | | | | | | 1.00 |

*. $p < 0.05$, two-tailed; **. $p < 0.01$, two-tailed.

## General Discussion

The development of a theory of mind (ToM) has established itself as one of the most prevalent research topics in the field of evolutionary, developmental, and clinical psychology in recent years. From an evolutionary perspective, the question of how ToM has evolved and whether the possession of a ToM is specific to human beings has intrigued philosophers and scientists alike. From a developmental standpoint, questions and hypotheses abound about the onset and progression of ToM knowledge and key developmental milestones. In turn, neuroscientists have addressed the question of whether mentalizing abilities are subserved by specific, dedicated mechanisms and have thus spurred extensive research on the neural basis of such complex mental states as desires, beliefs, and intentions. Research on ToM has also expanded beyond the realm of developmental psychology to include developmental and clinical psychopathology, with the hypothesis that deficiencies in ToM may account for neurodevelopmental disorders such as autism (Baron-Cohen, 1995). One of the most intriguing findings related to ToM knowledge is that autistic children seem to be significantly impaired in their ability to understand people as mental beings, which has prompted the proposal that a specific developmental delay in ToM is involved in childhood autism (Baron-Cohen, Leslie, & Frith, 1985).

Despite this plethora of research on ToM, significantly fewer empirical investigations have addressed the various claims that specific early social-cognitive abilities serve as precursors to a more mature ToM. Surprisingly, only recently have researchers started to rest this continuity hypothesis between ToM precursors, such as imitation, joint attention, and intentional understanding, and children's later ToM abilities.

The current study is the first to examine a longitudinal association between infants' early understanding of the A-I distinction and their more developed understanding of ToM. Considering that the ability to categorize objects into animate and inanimate domains, an ability which arises early in infancy, is considered a major milestone in cognitive development (Rakison & Poulin-Dubois, 2001), it is conceivable that the A-I distinction is another potential precursor to ToM. While important theories of children's mental abilities have traditionally considered biological understanding as a key component (Inagaki & Hatano, 2002), significantly less focus has been paid to the relationship between naïve psychology and naïve biology. As such, little is known about the extent of children's understanding across both naïve psychology and naïve biology. Furthermore, the developmental origins of naïve biology remain largely unknown, though the A-I distinction has been put forth as a potential precursor (Inagaki & Hatano, 2002). The current research therefore attempted to fill a gap in our knowledge of precursors of both naïve psychology and naïve biology by examining how the A-I distinction in infancy is related to later ToM and animacy concepts.

One of the central finding of the present study is the possibility of a longitudinal association between children's performance on the categorization task in infancy and their later understanding of ToM in Experiment 1. Specifically, it appears that infants' understanding that animals and not vehicles play the role of agents in motion and sensory events, somewhat predicted their later ability to pass the false-belief task. Although this finding was only marginally significant, it does raise intriguing questions about the reason for continuity between infants' early understanding of animacy and their later understanding that people's beliefs may differ from reality. Obviously, to hold a false belief or any other mental state, one must at least be animate. This is consistent with previous studies which have also found a correlation between early infant abilities and false belief performance at preschool age. For instance, Aschersleben, Hofer, and Jovanovic (2008) found that infants' decrement of attention to goal-directed action at six months of age was significantly related to their ability to pass a false belief task at four years. However, there is more to ToM than passing a false belief task. The failure to find an association between knowledge of the A-I distinction in infancy and the ToM battery as a whole suggests that any potential link between the A-I distinction in infancy and ToM at preschool age is very specific. This may be due to the fact that false belief is the most mature form of mentalizing, and the task (unlike others in the battery) that people with autism fail (e.g., Baron-Cohen, Leslie, & Frith, 1985). Furthermore, it is very possible that our small sample size may have obscured this underlying relationship and replication of these findings with a larger participant pool is warranted. As well, it is important to point out that a cognitive control measure at the preschool age (such as a measure of IQ) was not included. Therefore, it remains to be determined whether the observation of a longitudinal association between children's performance on the categorization task in infancy and their later understanding of ToM reflects a domain-specific effect or simply an indication that individual differences in domain-general abilities were observed. Future research should re-examine the relation between early concepts of animacy and overall ToM ability. A wider range of infancy tasks designed to assess a broader understanding of the animacy concept might be better suited to predict

ToM knowledge at preschool age. Also, the inclusion of tasks that tap domain-general cognitive abilities such as IQ are warranted.

The proposal that the A-I distinction in infancy may also be linked to later, more advanced, knowledge of naïve biology was another issue investigated for the first time in the present study. The ability to distinguish between living (animate) and non-living (inanimate) beings is fundamental not only for biological understanding but also for classifying objects into broad categories. In fact, researchers have considered the types of questions posed by children about living and artificial kinds as a means of determining the properties that children deem essential for conceptual categorization (Greif, Kemler-Nelson, Keil, & Gutierre, 2006). Greif et al. found that when preschool aged children inquired about unfamiliar artifacts and animals, they were more likely to ask about functions and behaviours for the artifacts (e.g. what is it for?) than about biologically relevant properties (e.g. eating behavior), which they reserved for animals. The results speak to children's conceptual knowledge of categories of living and non-living things, and "reveal a deep-seated conceptual contrast between animals and artifacts" (Greif et al., p. 458). Interestingly, results from Experiment 1 showed that performance on the A-I task administered in infancy strongly predicted performance on the animacy task at preschool age, even when language skills were controlled for. That is, infants' understanding of the conceptual categories of animate and inanimate beings was linked to a later understanding of animacy, whereby children who understood that animals are more appropriate than vehicles to perform both sensory and motion events had a better understanding of the concept of animacy at preschool age. This finding provides preliminary evidence of developmental continuity between the A-I distinction in infancy and a later more developed form of naïve biology, supporting the proposal that conceptual knowledge of animate and inanimate beings in infancy may indeed be a precursor to later biological understanding. Further, this is also an important finding in that domain specificity was established by the presence of a longitudinal relationship between two tasks that are thought to measure a common construct (i.e. animacy).

Another important finding that emerged from Experiment 1 was the discovery of a significant concurrent relationship between performance on the animacy and ToM tasks at preschool age. This suggests that the ability to reason about mental states is, to some extent, related to preschoolers' understanding of animacy (living/non-living) and sentiency (knowing/wanting). This is a reasonable notion in light of the function and exclusivity of certain mental states for a subset of animate beings. Specifically, animates are creatures that "know, perceive, emote, learn, and think" (Gelman & Spelke, 1981, p.45). This association between biological understanding and ToM lend credence to Inagaki and Hatano's (2002) claim that by four years of age, children have acquired a certain kind of biological framework for thinking about living things and extends this claim to include the idea that this biological framework might also be linked to children's knowledge of people as causal agents. This is further supported by the consistency in children's responses across the different categories of questions on the animacy-acceptability task. That is, preschoolers had a similar level of understanding of both animacy and sentiency at this age, suggesting that perhaps by this age, there is considerable overlap across children's knowledge of biological and psychological domains.

The findings obtained in Experiment 2 are less clear. It is important to note that the infancy induction task in Experiment 2 did not address the animate-inanimate distinction directly. That is, both the test exemplars (animals, people) as well as the model used to imitate the events (a monkey doll) were all animate beings. The key effect of the induction study, therefore, was the more frequent choice of the person over the animal for the sensory events than for the motion events, suggestive of some initial form of ToM knowledge. That is, the choice of the person over the animals might be indicative that infants have an early understanding that people have visual and auditory experiences that may not be applicable to animals. With this in mind, the fact that we did not find a relationship between the performance in the infancy task and later performance on ToM battery or false belief is unexpected. It may be that our choice of sensory properties (looking into a mirror, listening on a phone) was not a sensitive enough measure of infants' ability to infer 'psychological' properties exclusively to people. As such, it would be imperative for future research to assess if infants' ability to infer a wider range of psychological attributes to people would predict performance on a battery of ToM at preschool age.

In contrast to Experiment 1, we did not find a longitudinal relationship between performance on the induction generalization task in infancy and the animacy task at preschool age in Experiment 2. Despite the argument for continuity in the development of naïve theories put forth by various researchers in the field (e.g. Charman et al. 2000, Olineck & Poulin-Dubois, 2005, 2007), we found little direct empirical evidence in Experiment 2 to support this theoretical position. The lack of findings in Experiment 2 to support the existence of continuity might be interpreted as support for Inakgaki and Hatano's (1993, 2002) view that psychological and biological domains function independently of one another and that naïve psychology is simply a 'neighboring' theory that can at times penetrate into biological reasoning during that time when naïve biology is establishing itself. While this is plausible, it may also be that the two tasks employed in this experiment did not measure abilities sufficiently similar to establish continuity between the two time points. The small sample size could also have been a factor in why continuity was not established. Here too, a broader range of tasks that measure infants' ability to attribute biological properties might be better able to tap into infants' naïve biology knowledge and perhaps then establish continuity with later animacy knowledge, as measured by tasks such as Inagaki and Sugiyama's (1998). In addition, subsequent research should perhaps include tasks that employ methodological paradigms other than imitation to measure knowledge of animacy in infancy. Certainly, future research should address these issues.

The concurrent relationship between ToM and animacy at preschool age in Experiment 2 was also supported by a relationship between children's proportion of over-attribution errors on the anatomical properties and their performance on the ToM task. This relationship remained even when the effect of language was taken into account. In light of how little is known about children's understanding across both naïve psychology and naïve biology, this original finding strengthens the idea that there exists a relationship betweedn children's core domains of thought. Furthermore, it may also support the notion that the A-I distinction in infancy is indeed a precursor to the living/nonliving distinction (Inagaki & Hatano, 2002), but that naïve biology may simply be hard to test in infancy (and why consequently longitudinal findings are difficult to obtain), while the concurrent relationship between knowledge of biological properties and ToM at preschool age is more easily discernible.

Overall, the results of this set of studies are promising. Importantly, preliminary evidence was found for a developmental progression between the early understanding of A-I distinction and later knowledge of false belief at preschool age. As well, developmental continuity between the A-I distinction in infancy and a more developed form of naïve biology at preschool age was established, supporting Inagaki and Hatano's (2002) proposal that the A-I distinction in infancy might be a potential precursor to later naïve biology (Inagaki & Hatano, 2002). As previously mentioned, there are a number of notable limitations to the present set of studies. The small sample size, the lack of a relationship between performance on the infancy task and later performance on the global ToM battery, as well as the relatively limited aspects of animacy and sentiency that were measured in infancy are worth mentioning here. As well, the high number of correlations that were run on such a small sample size may have resulted in an increased risk of type I error. Notwithstanding these limitations, the findings establish the way for future research to further explore whether ToM knowledge has its roots in naïve biology and naïve psychology.

Chapter 3

# Domain-General Categorization in Young Children with Autism

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## Contribution of Authors

This section details the contributions of the first author in the article entitled "Domain-general categorization in young children with autism." The first experiment with typically developing children reported in this paper was conducted in the Cognitive Development Laboratory in the Centre for Research in Human Development at Concordia University, Montreal. The second experiment with autistic children was conducted at the child psychiatry department at the Montreal Children's Hospital of the McGill University Health Centre (MUHC).

The experimental methodology and research design for the first study was designed collaboratively by the second and third authors. The third author gathered the testing stimuli, devised administration orders (i.e., counterbalancing), and wrote the recruitment letters and consent forms for the first study. The data from this experiment was submitted as part of the third author's Masters thesis which was supervised by the second author. The experimental methodology and research design for the second study reported in this paper was designed collaboratively by the first and second authors. The first author gathered the testing stimuli, devised administration orders (i.e., counterbalancing), and wrote the consent forms.

A total of 31 typically developing children were tested in the first study and 16 children with autism spectrum disorder were tested in the second study. All the participants in the first study were tested by the third author who also explained the procedure to the parents. The participants in the second study were all tested by the first author, who met with the parents of these autistic children and explained the procedure and rational of the study to them.

With regards to coding and data analysis, the third author coded all of the children's responses in the first experiment by viewing taped recordings of the testing sessions. A second coder, naïve to the experimental hypotheses, independently coded 25% of the infants and inter-rater reliability was obtained. The third author then inputted the data into an SPSS worksheet and conducted all subsequent analyses. With respect to the second experiment, the first author coded all of the children's responses by viewing the taped recordings of the testing sessions. A second, independent coder, then coded a random selection of 29% of the children and overall inter-rater reliability was obtained. The first author inputted the data from this study into an SPSS worksheet and conducted all subsequent analyses on this study and on the comparative results of both experiments.

The first author wrote the abstract, introduction, results, and discussion sections of the first experiment reported in this paper. The methods section of Experiment 1 was written by the third author. For the second experiment, the first author wrote the introduction, method, results, and discussion sections. All sections were reviewed and commented upon by the second author. The final draft of the paper was reviewed and approved by the fourth author.

Abstract

The sequential touching task was administered to a group of typically developing 18-month-old infants and to a group of young autistic children in order to evaluate their ability to form an animate-inanimate distinction at the domain level. The typically developing infants categorized at the domain level whereas the autistic children categorized at the global but not the domain level. These findings suggest that typically developing children can form categories at a higher level of inclusiveness than has previously been demonstrated and that children with autism possess a concept of animacy, although this knowledge might be narrower than typically developing children.

## Domain-General Categorization in Children with Autism

Autism Spectrum Disorder (ASD) is a rare, yet severe and lifelong neurodevelopmental syndrome. One of the most striking and recognized symptoms of ASD is an impairment in the realm of processing social information, notably faces. Behaviourally, this social information processing deficit is translated into a tendency to withdraw socially and to engage in atypical eye contact, both of which are regarded as core clinical features of ASD (American Psychiatric Association, 2000). In recent years, considerable research has focused on different aspects of this social information processing impairment in both adults and children with ASD.

For instance, a number of studies on face processing in children and adults with ASD have demonstrated deficits in abilities such as remembering unfamiliar faces (Boucher & Lewis, 1992; Gepner, de Gelder, & de Schonen, 1996; Riby, Doherty-Sneddon, & Bruce, 2009) and recognizing previously familiar faces (Boucher, Lewis, & Collis, 1998). Electroencephalographic (ERP) studies of face recognition in both children (Dawson et al., 2002) and adults (McPartland, Dawson, Webb, Panagiotides, & Carver, 2004) with ASD have supplemented the previous findings by providing further evidence of a face recognition deficit in ASD. There is also substantial evidence of a deficit in the ability to follow eye gaze in ASD (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Leekam, López, & Moore, 2000). Indeed, autistic children as young as 20 months of age have been shown to demonstrate atypical eye gaze. In a study by Swettenham et al., (1998), 20 month old infants with autism were compared to two control groups (typically developing and non-autistic developmentally delayed) in terms of their spontaneous looking behaviour during a free play session. The authors found that the autistic infants spent less time looking at people than did both control groups and spent more time looking at objects.

The ability to recognize facial expressions or to decipher facial emotions has also been found to be problematic among autistic individuals (Ashwin, Baron-Cohen, Wheelwright, O'Riordan, & Bullmore, 2007; Celani, Battacchi, & Arcidiacono, 1999; Gepner et al., 1996; Teunisse & de Gelder, 1994). For instance, Riby et al. (2009) investigated the perception of a variety of facial cues, such as identity, eye-gaze, lip reading, and facial emotional expressions among autistic individuals between the ages of six and sixteen years. The results indicated that the autistic individuals had greater difficulty with eye-gaze and expression processing when compared to individuals with Williams Syndrome and individuals with a developmental delay.

In a study on brain activation in autistic individuals, Castelli, Frith, Happé and Frith (2002) suggested that the ability to perceive social information is linked to the processing of biological motion. Indeed, a myriad of studies have shown that typically developing infants, older children, and adults can distinguish biological from mechanical motion (Bonda, Petrides, Ostry, & Evans, 1996; Heider & Simmel, 1944; Tremoulet & Feldman, 2000). According to Rutherford, Pennington, & Rogers (2006), motion properties serve as the foundation upon which people are capable of perceiving social information. In the case of autism, recent research seems to suggest that individuals with ASD do not recognize biological motion in the same way that normally developing people do. In one such study, Blake, Turner, Smorski, Pozdol, & Stone (2003) looked at whether a deficit in perceiving motion is linked to the social deficits apparent in ASD. The authors tested children with and without ASD on their ability to distinguish biological from non-biological motion using point-light displays depicting normal biological arrangements as well as scrambled arrangements. The amount of time it took participants to recognize the point-light displays as ‘a person’ was examined. Although children with ASD performed equally well on a separate visual discrimination task compared to typically developing children, their performance on the point light display task was considerably impaired. That is, the autistic children had greater difficulty discriminating biological from non-biological motion than did their mental-age-matched controls. Additional studies using point-light display methods have produced somewhat consistent findings (Milne et al., 2002; Spencer et al., 2000).

In 2006, Rutherford et al. further examined the question of whether children with ASD can perceive animate motion much like typically developing children do. The authors reasoned that since the ability to discriminate animate from inanimate motion is a potential precursor for later social development in typically developing children, then the social deficit evident in autistic children might be linked to an early *inability* to discriminate animate motion from inanimate motion. Children with ASD and age-matched controls were shown simple geometric figures that moved on a computer screen in either an animate manner (i.e., accelerated, decelerated, or propelled itself) or inanimate manner (i.e., in response to impact or gravity) and were asked to identify which of the two figures moved as if it were animate. The results showed that in the initial training phase, children with ASD were impaired in their ability to categorize objects as animate compared to control groups. However, this deficit seemed to disappear once the children had mastered the ability to perceive animacy in the test phase. The authors interpreted these findings to suggest that “the mechanisms that perceive animacy are functional in autism and perhaps need to be primed, or that these children are able to quickly develop compensatory strategies" (p. 989).

Despite findings indicating that the detection of biological motion is impaired in individuals with ASD, there exist a number of studies to the contrary suggesting that the ability to detect biological motion cues is not affected in the autistic population. Moore, Hobson, and Lee (1997), for instance, found that children with ASD performed equally well as non-autistic children on tasks measuring the perception of biological motion. Fourteen-year-old participants with autism and age-matched controls (non-autistic children with mental retardation (MR) matched on verbal ability and chronological age) were asked to recognize human activity based on point-light animation displays. The results showed no statistically significant difference in the ability of the autistic and non-autistic individuals to recognize animate activity in brief point-light displays, even when the displays were shown for less than half a second. However, when it came to perceiving emotion-related attitudes and mental states based on motion cues, the autistic participants were significantly less capable of doing so than controls. More recently, Hubert et al., (2007) re-examined the question of biological motion perception among high-functioning adolescents and adults with autism, Asperger Syndrome and typically developing individuals matched on chorological age (CA) and gender. Participants were shown point-light displays of human actions, subjective states, and emotional actions. Consistent with Moore et al's findings, the authors found that the autistic and Asperger subjects were capable of perceiving biological and non-biological activity, but were significantly impaired in their ability to describe emotional states depicted in the point-light displays of bodily actions.

The extent to which autistic children possess a concept of animacy is an intriguing question. According to Mandler (1992, 2000), the processing of dynamic properties of objects (including biological motion) is fundamental for the early ability to recognize objects as either animate or inanimate, an ability which is considered a cognitive milestone in typical development (Gelman & Opfer, 2002; Rakison & Poulin-Dubois, 2001). The literature on infants' earliest categorical distinctions points to differing perspectives on the development of the animate-inanimate (A-I) distinction in infancy. Objects can be categorized at different levels of abstraction. For example, the basic-level category 'dogs' belongs to the global category 'animals,' which itself belongs to the larger ontological category of 'animate beings' (Mervis & Rosch, 1981). Along these lines, it has been proposed that infants begin by forming basic-level categories that are easily distinguishable based on perceptual cues, and that eventually, these categorical representations become conceptually-based.

A different view on the development of categorization in infancy suggests that although early categories do not correspond to the global or ontological level of adults, they are indeed broad in nature (Mandler & Bauer, 1988; Mandler & McDonough, 1993, 1998). A large body of research supports the hypothesis that global categories actually develop before basic-level categories during the first two years of life (Mandler, 2000; Mandler, Bauer, & McDonough, 1991; Mandler & McDonough, 1998; Pauen, 2002; Poulin-Dubois, Graham, & Sippola, 1995). Both featural (faces, contour) and dynamic (contingent motion, self-propulsion) information is used by infants to form these broad categories (Rakison & Poulin-Dubois, 2001). In one study, 16-month-old typically developing infants generalized motion properties from people to animals, suggesting that by this age, infants consider biological motion as appropriate to the broad animate domain (Poulin-Dubois, Frenkiel-Fishman, Nayer, & Johnson, 2006). The conventional approach to the study of infants' and children's category knowledge has been the inductive generalization paradigm which involves the imitation of properties modeled. While appropriate when conducting studies with a typically developing population, an approach that relies upon modeling or imitation is not suitable when testing autistic children given the latter's imitative deficit (Rogers & Pennington, 1991; Rogers & Williams, 2006; Smith & Bryson, 1994).

Another paradigm often used to study infant categorization is the sequential touching procedure. This technique involves presenting infants with an array of objects consisting of exemplars from two categories (e.g., animals and vehicles). The touching behavior of the infants is examined in order to determine whether there is any systematic order to their touches. Infants are considered to have categorized the objects if they touch multiple objects from the same category before touching objects from the other category. Studies using the sequential touching procedure have found that typically developing infants can categorize objects at a basic level at 16- and 20-months of age, though only when the basic-level categories could be subsumed under differing superordinate categories (Mandler & Bauer, 1988). Specifically, these authors found that infants could categorize dogs vs. cars (dissimilar superordinate-level categories) but not cars vs. trucks (similar superordinate-level category) and therefore posited that the understanding of superordinate-level categories develops prior to that of basic-level categories. Mandler et al., (1991) found similar results using a sequential touching task with 18-month-old infants. That is, infants were able to differentiate superordinate-level categories (animals vs. vehicles) but not basic-level categories of low contrast (e.g., dogs vs. horses) or moderate contrast (e.g., cars vs. motorcycles). The only evidence of basic-level categorization was found using a high degree of contrast (e.g., dogs vs. fish). By 30 months of age the infants were capable of discriminating low and moderate degrees of contrast at the basic level. This area of research was extended by Poulin-Dubois et al. (1995) to include superordinate-, basic-, and subordinate-level categories. Using a sequential touching task, the authors found evidence of superordinate-level categorization (e.g., animals vs. furniture) by 15 months of age, followed by basic-level categorization (e.g., cars vs. trucks) at around 20 months of age. The infants did not display evidence of subordinate-level categorization (e.g., collies vs. German shepherds) even by 25 months of age.

Evidence of the obtainment of superordinate-level categorization prior to that of basic-level categorization has been found with even younger infants using the object examination procedure in which infants are presented, one at a time, objects from one category followed by a novel object from a different category. The amount of time the infant took to examine the item from the new category is measured. Using this task, Mandler and McDonough (1993) found that both 9- and 11-month-old infants were found to categorize superordinate-level categories of animals and vehicles. Using the same task, Pauen (2002) discovered that 8-month-old infants were capable of categorizing objects at the superordinate level, but not at the basic level. By 12 months of age, the same infants were able to demonstrate basic-level categorization. Taken together these results support the hypothesis of a superordinate-to-basic-level progression of categorization in early infancy.

Research on categorization processes in ASD is somewhat limited. In 1987, Ungerer and Sigman examined autistic children's ability to sort objects into categories using perceptual (e.g., color) and functional (e.g., furniture) cues. Preschool-aged autistic and MR children were matched on chronological age (CA), mental age (MA), and IQ. A third comparison group consisted of typically developing children matched on CA. Using the sequential touching paradigm, the authors found no significant differences among the autistic, MR or typically developing children in the percentage of objects touched that belonged to the same category, for both the perceptual and functional tasks. That is, autistic children were as capable of forming categories based on function, form, and color as MR and MA matched normally developing children. Other early studies of categorization abilities in autistic individuals have produced similar findings, suggesting that category formation based on *spatial* or *perceptual* attributes in ASD is not impaired (Lancy & Goldstein, 1982; Tager-Flusberg, 1985).

A growing number of studies seem to suggest that individuals with ASD can successfully form categories when categorization is based on simple, perceptual cues but have greater difficulty when more *abstract* or complex reasoning is required. For instance, Shulman, Yirmiya, and Greenbaum (1995), found that when classification was based on perceptual features, such as the ability to sort geometric shapes, autistic children's performance on sorting tasks was comparable to that of children with MR and normally developing children. In contrast, the autistic children's ability to sort representational objects (based on more abstract criteria) was significantly impaired in comparison to the other groups of children. Several other studies lend credence to the notion that categorization or concept formation based on more abstract or superordinate representations is problematic for individuals with ASD (Klinger & Dawson, 2001; Minshew, Meyer, & Goldstein, 2002; Plaisted, 2000).

It has been suggested that a deficit in understanding biological motion properties in ASD could be manifested as a disability to group categories together, specifically that of abstract or global categories for animates and inanimates. Only one other study has examined whether children with ASD are able to use information about motion properties to form an A-I distinction (Johnson & Rakison, 2006). Using a modified version of the inductive generalization task, 11 children diagnosed with ASD were administered four separate events, each depicting a different type of motion appropriate to either animates (e.g., a dog walking) or inanimates (e.g., a car rolling). Following a baseline phase during which children explored the objects, the experimenter modeled four target motions with toy replicas of animals or vehicles. The child was then encouraged to imitate the previously modeled motion for the generalization part of the study. The test exemplars consisted of props that differed in terms of whether or not they belonged to the superordinate category of the motion tested and in whether or not they possessed the correct and functional parts for the motion. The authors found that children with ASD correctly generalized functional *parts* for animate (i.e., legs for non-linear trajectories) and inanimate (i.e., wheels for linear trajectories) land motions, even if the props did not belong to the correct superordinate category (e.g., using a table to imitate a non-linear land motion); performance that the authors maintain is consistent with that of 18-month-old typically developing children and is suggestive of a rule-based approach to categorization. In contrast, the children correctly generalized to the superordinate category for both animate (e.g., an eagle flying non-linearly) and inanimate (e.g., a plane flying linearly) air motions. Although the current findings seem to suggest that children with ASD have an understanding of the motion properties specific to animates and inanimates, it is important to note that the highest percentage of action obtained in this study was 24%, which is considerably less than that observed among typically developing children. In Mandler and McDonough's 1996 study, for example, the percentage of action with the target exemplar at generalization reached 67%, with similar results also obtained when atypical animal and vehicle exemplars were used. Further, the methodology used in Johnson and Rakison's (2006) study to assess children's knowledge of the motion properties of animate and inanimates is questionable with an ASD population in light of research supporting an autism-specific deficit in imitation (Charman et al., 1997; Rogers, Hepburn, Stackhouse, & Wehner, 2003).

Surprisingly, to date, no study has examined whether infants can form categories at a higher level of inclusiveness than animals, people, vehicles, and furniture. For example, if infants start with a broad animate category, they should group people and animals together in one category. Similarly, if they possess a broad inanimate category, they should group vehicles and furniture together. The main goal of the current paper was to examine young autistic children's ability to categorize animate and inanimate objects at a domain-general level. In Experiment 1, a control group of typically developing children was administered a sequential touching task to assess their knowledge of the broad A-I distinction. The goal of Experiment 2 was to examine young autistic children's ability to form this domain-general, A-I distinction. Previous research examining the categorization abilities of autistic children has mainly used tasks in which geometric figures are employed (e.g., Tager-Flusberg, 1985). As such, small replicas of real-life objects were used in order to determine whether autistic children can classify objects into animate and inanimate categories using the sequential touching task.

## Experiment 1

The goal of the current study was to examine typically developing infants' understanding of the broad, domain-general, A-I distinction.

### Method

#### Participants

Thirty-one 18-month-old infants (*M* age = 18.61 months, *SD* = .65, *range* = 17.41 to 19.67 months) participated in Experiment 1. The sample consisted of 19 males and 12 females. Two additional infants participated but were excluded due to parental interference (*N* = 1) and fussiness (*N* = 1). Families were recruited through birth lists provided by a governmental health office. All infants were born full-term and had no visual or auditory difficulties as reported by parents. See Appendix J for a sample recruitment letter.

#### Materials and Procedure

Small, plastic three-dimensional objects were used. The animate domain exemplars consisted of eight people (African American man, African American woman, African American boy, African American girl, Caucasian man, Caucasian woman, Caucasian boy, Caucasian girl) and four animals (dog, cow, dolphin, eagle). The inanimate domain exemplars consisted of four vehicles (truck, car, boat, airplane) and four pieces of furniture (chair, desk, bed, bathtub). The objects were presented to the infant on a 44.80 x 34.60 cm tray. A brown cloth was used to cover the objects, and a stopwatch was used to monitor trial length. The testing session was recorded through a Sony video camera on a Hi-8 video cassette tape.

The infants and their parent(s) were greeted in a reception room arranged as a playroom. During a brief warm-up period, the experimenter interacted and played with the infant to familiarize him/her with the new environment and the experimenter. During this time, the parent was asked to sign a consent form and to complete a participant questionnaire. Once the child appeared comfortable with the setting, the parents and their child were brought to the testing room. A sample parent consent form is provided in Appendix K.

The infant was seated either on his or her parent's lap or in a clip-on chair attached to the table, with the parent sitting directly behind. The experimenter was seated directly across the table from the infant. Prior to the testing session, the objects were selected from one of six testing arrays. Each array consisted of eight objects, four from the animate domain and four from the inanimate domain. These objects were arranged on the tray in a random fashion, and then covered with the brown cloth. The tray was kept on a table next to the experimenter, and was out of the infant's view. After the infant was seated, the tray was placed on the table in front of the experimenter, but out of the infant's reach. The experimenter removed the cloth and made a sweeping hand motion over the tray while saying "Look at all of these toys. These are all for you." The tray was then pushed towards the child, and he or she was given 2 min to freely manipulate the objects. No further prompting was given unless the child did not touch any new object (or touched no objects) for more than 30 s, in which case the sweeping hand motion and original statement were repeated. If an object fell off the table, the parent or experimenter picked it up and inconspicuously placed it back on the tray.

Coding and Scoring

Children's sequential touching behaviour was coded. Consistent with previous studies employing the sequential touching task (Mandler, Fivush, & Reznick, 1987; Poulin-Dubois et al., 1995; Rakison & Butterworth, 1998), a 'touch' was coded when the child made physical contact with an object, either with his/her own hand, finger, or with the use of another object. The touch must have been judged as intentional, with the child focused on the object being touched (Oakes et al., 1996). Accidental touches (e.g., coming into contact with an object while reaching for another) did not qualify as a 'touch.' As well, a coding scheme was developed based on the rules outlined in Poulin-Dubois et al. (1995) and Starkey (1981). Specifically: 1) coding began once all the toys were presented on the table and the child touched a toy, 2) if a delay of more than 10 s occurred between touches, a break in the sequence of objects touched was recorded. The 10 s break criterion is used in sequential touching coding because if a significant length of time has passed between two touches, the infant may not make any conceptual link between them. That is, a touch to the desk exemplar followed 25 s later by a touch to the truck exemplar may not be evidence of inanimate categorization. However, a short time interval between touches can be interpreted as more likely that the child has associated the two objects. If a 10 s break was recorded, it would interrupt any ongoing run, 3) a touch was not counted as a part of the sequence if the child's touch was a result of the experimenter or parent drawing his or her attention to the object, or if the child immediately touched a toy that had fallen and been replaced on the tray, 4) if the child touched the same toy twice or more in succession (without a 10 s delay) or if the child simultaneously touched two objects from the same category, it was counted as a single touch, 5) if the child simultaneously touched two objects from different categories, it was not considered a touch and a break in the sequence was recorded, and 6) if the child focused on and touched a new object while still manipulating another object, a touch was recorded for the new object. The administration protocol for the sequential touching task used throughout this paper is provided in Appendix L.

The sequence in which the objects were touched was noted. Procedures for analyzing sequential touching were consistent with those developed by Mandler et al. (1987). The first procedure determined whether children sequentially touched objects that belonged to the same category more frequently than would be expected by chance. The mean run length (MRL) of successive touches, as defined by a sequence of deliberate touches to exemplars from the same category preceding a 'break' in sequence as a result of touching an exemplar from a different category, was calculated for each child and then averaged for the group. According to Mandler et al. (1987), children who touch multiple objects from the same category in a sequence that is greater than expected by chance are considered to have selected objects into categories based on some level of similarity, a behaviour that is interpreted as being systematic and category-driven (Oakes & Rakison, 2003). For a task that includes two categories of four objects each, chance value is 1.75 (Mandler et al. 1991). The coding protocol for the sequential touching task used throughout this paper is provided in Appendix M and the coding form is provided in Appendix N.

Although MRL analyses are informative when it comes to categorical abilities of groups of individuals, this type of analysis tells us little about an individual child's knowledge of categories, nor of the type of touching that took place. Therefore, an additional approach for analyzing children's sequential touching was employed in order to ascertain whether a child's touches were aimed more towards one category than another, or equally to both categories. As outlined by Dixon, Price, Watkins and Brink (2007), children's sequential touching was coded for 'special' runs, which consist of touching a minimum of three different objects from the same category (either animate or inanimate) in succession. Based on these special runs, each participant was then identified as a noncategorizer, a single categorizer, or an exhaustive categorizer. Noncategorizers refer to participants with no special runs in either category. Single categorizers refer to participants with at least one special run in only one category (animate *or* inanimate). Finally, exhaustive categorizers refer to participants with at least one special run in both categories (animate *and* inanimate). The entire sequences of touches containing the special runs were then entered into a Monte Carlo program, TouchStat 3.0 (Dixon & Watkins, 2004), to determine if they were likely to have occurred by chance. The program then simulated 10,000 random touch sequences in order to determine the frequency of occurrence of these special runs. Based on Mandler et al. (1987), a probability lower than .10 ($p$ <.10) signified that the participant's run was unlikely to be due to chance alone. Based on the probability results, we determined whether each participant still qualified for their single categorizer or exhaustive categorizer status. More specifically, if the resulting probability value was found to be above .10, the child was then moved to the non-categorizer category, whereas if the resulting probability value was found to be below .10, the child remained in the single or exhaustive category. The percentage of participants in each category was then calculated.

Inter-coder Agreement

A second coder naïve to the experimental hypothesis independently coded 25% of the infants (at least one infant from each testing array). Interrater reliability was obtained by calculating a percentage of agreement for the order in which the items were touched. Average agreement was determined to be 88%.

## Results and Discussion

Run length analysis

One-sample t-tests were used to compare infant MRLs to the MRL expected by chance (1.75). Preliminary analyses revealed no significant gender differences in MRL, and therefore all analyses were collapsed across gender. The infants had an average MRL ($M = 2.02$, $SD = .73$) that was significantly greater than chance, $t(30) = 2.07$, $p = .047$, $d = .76$. This suggests that at least by 18 months of age, typically developing infants have an understanding of the broad A-I distinction.

Monte Carlo analysis

With the use of a Monte Carlo program, children's categorization of 'special' runs (a minimum of three different objects touched from the same category in succession) was compared to chance. A total of 51.6% of the children were identified as noncategorizers, 32.3% as single categorizers, and 16.1% as exhaustive categorizers.

This study addressed the question of conceptual categorization at the broadest level – that of animate and inanimate domains – in 18-month-old infants. Previous research using the sequential touching task has shown that by 18 months 73% of infants are capable of forming categories at the global level (e.g., animal and vehicle) while only 30% succeed at doing so at the basic level (e.g. dogs and horses) (Mandler et al. 1991). The current study was the first to determine that by this age, 48% of infants can also form categories at a higher level of inclusiveness. While the lower percentage of children who are able to form domain level categories at this age suggests that this may be a more conceptually demanding task, our finding does confirms the developmental trajectory proposed by Mandler (2003) whereby children first acquire broad categories, and learn to distinguish among the narrower, lower-level categories as their age increases. The discovery of successful domain-general categorization at 18 months in typically developing infants prompted us to examine this level of categorical knowledge in a population of children with developmental difficulties in the social domain. By comparing domain-level categorization with an older group of autistic children, we addressed whether children with ASD form object categories in the same way as normally developing children.

## Experiment 2

The goal of Experiment 2 was to examine young autistic children's ability to form an A-I distinction. In addition to the domain-level categorization administered in Experiment 1, global and basic levels of categorization were also administered in order to assess the progression of category acquisition among children with ASD.

### Method

#### Participants

Sixteen 41-month-old children (*M* age = 41.39 months, *SD* = 9.82, *range* = 25.49 to 54.00 months) participated in Experiment 2. The participants were all children diagnosed with autism who were taking part in a large-scale longitudinal study looking at the developmental trajectories in children with ASD and the factors associated with optimal outcome. At the time of testing, the large-scale study was still ongoing at a hospital in Montréal, Québec. Prior to beginning an intensive data collection procedure, all participants were diagnosed with ASD by clinical opinion, the ADI-R, and the ADOS, and had a non-verbal mental age of 18 months (the minimum needed to do the ADI-R). There were three girls and 13 boys, all from the greater Montréal area.

Materials and Procedure

The stimuli consisted of objects belonging to either the animate or inanimate domain. The stimuli used to test children's understanding of the animate domain consisted of eight different people figurines (Caucasian woman, Caucasian man, Caucasian girl, Caucasian boy, African-American woman, African-American man, African-American girl, African-American boy) and eight replicas of animals (cow, dog, dolphin, eagle, horse, pig, rabbit, elephant). Children's understanding of the inanimate domain was examined with the use of eight vehicles (car, boat, airplane, truck, bike, van, canoe, and helicopter) and eight pieces of furniture (desk, chair, bed, bath, lamp, table, sofa, and dresser). Children's ability to make global-level and basic-level distinctions was also examined. For the global-level trial, children were presented contrasts such as animals vs. vehicles, animals vs. furniture, people vs. vehicles, or people vs. furniture. For the basic-level trials, children were presented with contrasts such as dogs vs. cats, tables vs. chairs, or planes vs. cars. For any given trial, four objects from each of the two categories tested were presented to the child on a red tray measuring 44.80 x 34.60 cm. A handheld stopwatch was used to time each trial. The testing session was recorded through a video camera on a VHS cassette.

Testing took place in a room with a one-way mirror at a hospital in Montréal. The sequential touching task was administered prior to another research-related study administered by hospital staff. Each child sat on a chair across a small table from the experimenter. The parent sat behind the child and was asked not to influence the child's behaviour by commenting in any way or by calling attention to any of the toys during the study. In the case where a child left his or her seat, the parent was to simply assist the child back to the table without intervening in the study. The experimenter presented the child with four items from each category in a random fashion on a red tray. The tray was positioned in front of the child, within his or her reach. The experimenter encouraged the child to play with the objects on the tray by motioning broadly to the entire set of objects while saying "Look at these…. These are for you to play with." The children were allotted two minutes and 30 seconds to manipulate and play with the objects freely, with no feedback about their touching behaviour. If a child turned around to look at his or her parents, the experimenter attempted to redirect the child's attention to the tray of objects by saying "CHILD'S NAME, Look at the toys!" In the case where a child ignored certain objects (i.e., did not touch the objects at all), the experimenter highlighted the objects by waving her hand in a circular manner above the objects (without pointing at any specific toy) and said "CHILD'S NAME, Look at these!" If the child dropped an object or an object was out of his or her reach, the experimenter unobtrusively placed the object on the tray within the child's reach.

Each testing session included three trials. In the first, *domain-level* trial, children were presented with a collection of four objects from the animate category (e.g., two people and two animals) and four objects from the inanimate category (e.g., two vehicles and two pieces of furniture) and their pattern of touching was observed. In the second trial, the children were presented with a different set of eight objects in order to assess their *global-level* understanding of the A-I distinction. For instance, children were presented with contrasts as diverse as animals vs. vehicles, animals vs. furniture, people vs. vehicles, or people vs. furniture. The different global-level contrasts were randomly assigned across subjects. In the third trial, children's *basic-level* categorization knowledge was examined by assessing whether children attend to basic-level distinctions such as dogs vs. cats, tables vs. chairs, or cars vs. planes. The presentation of trials (i.e., domain-, global-, and basic-level) as well as the types of contrasts presented for the global- and basic-level trials were counterbalanced across subjects.

<u>Coding and Scoring</u>

The coding scheme for recording children's sequential-touching behavior was identical to that of Experiment 1. As well, the procedures for analyzing sequential touching were the same as those of Experiment 1, with the addition that an overall MRL was calculated for each category level (domain, global, basic).

<u>Inter-coder Agreement</u>

The primary researcher coded all the data. A second, independent coder, then coded a random selection of 29% of the children (N =5). A percentage agreement between the different objects touched was obtained. Overall percentage reliability for objects touched by the children was 93% for the domain-level trials, 94% for the global-level trials, and 88% for the basic-level trials.

## Results and Discussion

Run length analysis

In the first analysis, the MRL for each category level (domain, global, basic) was compared to the MRL expected by chance (1.75) in order to determine whether children were responding in a way that was significantly different from that expected by chance. Two participants were eliminated from all analyses due to their performance on the basic trial. More specifically, these participants played exclusively with the cars and ignored the planes altogether on the cars vs. planes trial, resulting in a car bias. Since these two participants' domain- and global-level trials consisted of contrasts which included vehicles, we opted to exclude them from all subsequent analyses. One-tailed t-tests (test value = 1.75) for the domain and basic levels were not statistically greater than expected by chance (domain: $t(13) = .86$, $p = .21$, $d = .48$; basic: $t(13) = .47$, $p = .32$, $d = .26$), whereas the result for the global level was significant ($t(13) = 2.73$, $p = .01$, $d = 1.51$), indicating that the children exhibited some systematic behavior when touching items that belonged to global categories of animals or people versus furniture or vehicles. These MRL results provide preliminary evidence that autistic children can categorize at a more global level. The MRLs for each category level, and their respective t-tests (one-tailed) are shown in Table 6.

Table 6

*Mean Run Lengths, Standard Deviations, and Associated t-Test Values in Experiment 1 and Experiment 2.*

| | 18-month-old typically developing | | | 42-month-old autistic | | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *t*(30) | *M* | *SD* | *t*(13 ) |
| Domain | 2.02* | 0.73 | 2.07 | 1.66 | .41 | .86 |
| Global | -- | -- | -- | 2.24* | .66 | 2.73 |
| Basic | -- | -- | -- | 1.68 | .53 | .47 |

*Note.* Values enclosed in parentheses represent degrees of freedom.

* Indicates significantly above chance MRL (1.75), $p < .05$ (one-tailed)

Children's categorization abilities were further examined with a repeated measures ANOVA comparing the three levels of categorization: domain, global, and basic. If children with ASD do indeed categorize efficiently when simple, perceptual cues are involved but have greater difficulty with more abstract concept formation, then we would expect them to form lower-level categories before higher-level ones, supporting other findings that children with ASD often focus on narrower parts of the environment. Results showed that there was a significant effect of categorization level on children's sequential touching as measured by their MRL, $F$ (2, 26) = 4.45, $p$=.02, $n^2p$ = .26. Pairwise comparisons (with Bonferroni corrections) revealed that children had a statistically higher MRL on the global trial ($M$ = 2.24, $SD$ = .66) than on the domain trial ($M$ =1.66, $SD$ =.41), $p$ = .03. As well, there was a statistical trend favoring the hypothesis that global categories ($M$ = 2.24, $SD$ = .66) actually develop before basic-level ones ($M$ = 1.68, $SD$ = .53), $p$ = .13. Overall, the run length analyses seem to suggest that these children with ASD, as a group, were sequentially touching objects from the same category in a systematic fashion when presented with global categories of animals or people versus furniture or vehicles, but were less able to do so when more abstract categories were involved.

Monte Carlo analysis

Monte Carlo simulations (cutoff value of p <.10, see page 95 for details) on the domain level trial revealed that 71.4% of the children were identified as noncategorizers, 14.3% as single categorizers, and 14.3% as exhaustive categorizers. On the global level trials, 21.4% of the children were identified as noncategorizers, 50.0% were identified as single categorizers, and 28.6% as exhaustive categorizers.

Comparative analyses

Knowledge of typically developing children's categorization abilities can often be informative when examining differences in populations of children who experience developmental difficulties. As such, we were interested in whether children with ASD categorize differently from typically developing children.

First, one-sample t-tests were used to compare the mean CA of the typically developing children to that of the ASD group. The ASD group were significantly older ($M$ = 41.39 months, $SD$ = 9.82) than the typically developing group ($M$ = 18.61 months, $SD$ = .65), $t(45) = 13.00$, $p <.000$, $d = 3.27$. Although a measure of mental age was not obtained for the control group, the autistic sample had a minimum mental age of 18 months (the minimum required for completion of the ADI-R), enabling us to derive comparisons between the two groups' categorization knowledge. It is expected that the older ASD group would perform as well, if not better, than the typically developing group in the absence of any categorization deficits. However, if indeed individuals with ASD do not form social categories in the same way as normally developing children do, as has been suggested in the literature, then we would expect to see a difference when comparing the MRL of the ASD group to that of the typically developing children. We therefore compared the typically developing 18-month-old children's performance on the domain level to that of the autistic children. An independent sample t-test conducted on the A-I MRL of the domain trial reached marginal significance, $t(43) = 1.75$, p = .09, $d$ = .61, indicating a difference in the categorization abilities of these two groups. Consistent with the run length analyses, it appears that the typically developing children were able to categorize at the domain level, whereas the ASD group had greater difficulty doing so.

## General Discussion

Despite the enormous strides that have been made in the past two decades in understanding the nature of the deficits in autism, there remain many unanswered questions about the development of autism in infancy and early childhood. Specifically, although autism appears to have a distinct presentation by the age of three, the literature suggests that it is surprisingly difficult to detect at an earlier age. Therefore, there is a paramount need for tasks that tap into the deficits evident early on. Given that the A-I distinction is a significant milestone in early typical cognitive development, it seemed important to determine whether this accomplishment was also present in the case of autism. Ultimately, if a deficit exists in the ability to form an A-I distinction among children with ASD, then potential tasks that assess the ability to form conceptual categories of animates and inanimates might be beneficial in the early detection of autism.

The study of categorization at a domain level (e.g., animates vs. inanimate objects) allows us to explore the developmental precursors of the essential distinction between living and non-living beings that develop during the preschool period. The animate and inanimate domain-general categories we tested here have hardly been explored scientifically, despite researchers arguing that the A-I distinction is acquired relatively early in infancy (Rakison, 2003; Rakison & Poulin-Dubois, 2001). Previous research using a sequential touching task has found that infants from 12 to 30 months of age will sequentially touch items from the same basic- and global-level categories, with the primacy of the global level at 16 months, followed by the basic level at 24-30 months (e.g., Mandler & Bauer, 1988; Mandler et al., 1991; Oakes et al., 1996). This developmental pattern was replicated in our sample of 18-month-old infants. More importantly, the 18-month-olds in the current study also sequentially touched items from the same *domain-general* categories of animates and inanimates. Domain-general categorization is the ability to classify objects as animate (e.g., person, animal) or inanimate (e.g., vehicle, furniture) at the highest level of inclusivity, making the present set of studies the first to examine a level of categorization above the global level. Previous research examining such abilities in a more indirect way has indicated that infants have developed a concept of animates by 16 months of age (Poulin-Dubois et al., 2006). Such findings suggest that at this developmental stage, infants understand that objects within the animate domain share common features and reveal the existence of conceptual knowledge in infancy. The results from Experiment 1 supplement such findings by demonstrating that by the middle of the second year of life, infants are also capable of distinguishing domain-general categories.

The extent to which the acquisition of categorization abilities in typical development is applicable to populations of children who experience developmental difficulties is vitally important knowledge. As such, the current paper also aimed to shed light on autistic children's ability to form an A-I distinction so as to further our knowledge of autistic children's categorization abilities, and to decipher to what extent their ability to group categories together differs from typical development. The sequential touching task was deemed most appropriate as the method with which to test autistic children's category knowledge given its unstructured format and emphasis on spontaneous touching behaviors, and not on imitative abilities. Based on sequential touching run lengths, the results of Experiment 2 suggest that children with ASD between the ages of two to four and a half years differed from the typically developing group in the ability to categorize at the domain level. The ASD children were capable however of categorizing at a global level, indicating that children with ASD are indeed capable of forming conceptual categories, though not at the highest level of inclusiveness. That the ASD group was able to categorize at the global level lends credence to the notion that the detection of biological features is not completely impaired in individuals with ASD, as indicated by their ability to differentiate animate categories from inanimate ones. This is consistent with Rutherford et al.'s (2006) assertion that the mechanisms responsible for the perception of animacy are functional in autism. The more abstract level of conceptual knowledge of the *broad* animate domain has not yet been achieved however. Nonetheless, it does appear from the current findings that the autistic group's category acquisition follows the same development progression as that of typically developing children, as evidenced by the fact that they were able to master more inclusive levels first. That is, the autistic children's average run length was longer at the global level than at the basic level, consistent with research indicating that global categorization is acquired prior to basic-level categorization (e.g. Mandler & Bauer, 1988; Mandler & McDonough, 1993; Poulin-Dubois et al., 1995; Rostad, Poulin-Dubois, & Yott, 2009).

In considering these results, it is important to note that the current study did not control for MA, making it difficult to draw explicit comparisons between the cognitive development of the ASD group and that of the typically developing group. To afford more precision in the comparisons between the groups of children tested, these findings should be replicated in a similar design but with restrictions on CA and MA. In a study by Gopnik & Meltzoff (1992), infants who formed categories had a greater likelihood of producing more object names. In light of such research showing a link between categorization and naming, also placing restrictions on the participants' language ability can only further our ability to speak of the impact of categorization abilities in autism on other skills such as language development. In addition, testing typically developing children on the same global and basic levels of categorization as those administered to our ASD group would allow for more conclusive inferences about a common developmental progression in categorization among the two groups.

Research has repeatedly demonstrated that the benefits of early intervention in ASD are unquestionable and underscore the need for effective early identification. Despite these findings, the average age for diagnosis is still three to four years (Filipek et al., 1999). This delay in diagnosis is even more surprising given research showing that parents often recall noticing developmental delays or deficits in their child between 12 and 19 months of age (De Giacomo & Fombonne, 1998), and that abnormalities in social communicative behaviour often manifest themselves before 20 months of age (Baron-Cohen et al., 1996; Cox et al., 1999). As such, replicating this study with a group of children between the ages of 18 months and three years *at risk* for autism would allow for the use of information about their ability to form conceptual categories of animates and inanimates in the early detection of autism. Should it be further established that children with ASD are indeed delayed in their ability to form various levels of conceptual categories, then tasks that assess their ability to form conceptual categories of animates and inanimates might be beneficial in the early detection of autism.

Future research in this area is sorely needed, especially in light of evidence that autistic children who benefit from early intervention during preschool years show significant improvements in a number of different areas including language (Bondy & Frost, 1995; Harris, Handleman, Gordon, Kristoff, & Fuentes, 1991), communication skills (Koegel, 2000), imitative skills (Ozonoff & Cathcart, 1998), IQ (Lovaas, 1987; McEachin, Smith, & Lovaas, 1993), and disruptive behaviours (Scattone, Wilczynski, Edwards, & Rabian, 2002). For a review of research on the early detection and intervention in children with autism, see Bryson, Rogers, and Fombonne (2003).

Despite the limitations of our study, our findings that autistic children of preschool age can categorize at the global but not the domain level will hopefully inspire future research seeking to resolve some of the mystery surrounding the social information processing impairment in ASD. An understanding of autistic children's ability to form an A-I distinction will further our knowledge of autistic children's categorization abilities, and has implications for the early detection of autism.

# Chapter 4: Conclusion

Over the past two decades, research on children's conceptual development has focused a great deal on children's understanding of psychological and biological phenomena. Theory of mind (ToM) ability, for instance, has been studied extensively as a core domain of children's social understanding and is often discussed as a significant developmental achievement that has its roots in early infancy. Research in developmental psychology has also focused on what children know about other core domains of thought, including that of the natural world, such as biology and physics. Increasingly, studies on children's knowledge of the mind and the world that surrounds them have begun to address the question of what children understand about these domains and at what point they begin to develop that understanding. Indeed, contemporary discussions of children's core domains of thought such as naïve psychology and naïve biology have begun to promote the idea that continuity exists between certain early infant abilities and later preschool accomplishments in these realms. Surprisingly however, very few empirical studies have examined children's thinking across both naïve psychology and naïve biology. The current dissertation endeavors to resolve this omission in the literature. As such, one main objective of this dissertation was to further examine the roots of children's knowledge about naïve psychology and naïve biology in early infancy as well as to explore the extent of children's understanding across these two core conceptual domains of thought. Another focus was the exploration of a relationship between a potential precursor of naïve biology in infancy and Autism Spectrum Disorder (ASD), a disorder characterized by a social information processing deficit that may well be related to the processing of biological motion.

Summary of Findings

The goal of the first paper (Frenkiel-Fishman & Poulin-Dubois, submitted) was threefold. One goal was to examine whether continuity exists between typically developing infants' early understanding of the biological differences between animates and animates (A-I) and their more developed knowledge of ToM during the preschool years. A second goal was to examine whether continuity exists between this early understanding of the A-I distinction in infancy and a later more developed form of naïve biology. Lastly, the concurrent relationship between naïve psychology and naïve biology during the preschool years was examined. Two longitudinal studies were conducted in order to address these important questions. In the first longitudinal study, infants participated in a generalized imitation task at 16 or 20 months of age which assessed their ability to generalize target properties to the animate (e.g. animals) and inanimate (e.g. vehicles) domain. The participants then returned to the laboratory at 64 months of age and were administered a battery of five ToM tasks as well as an animacy acceptability task. In the second longitudinal study, a slightly modified generalized imitation task was administered to infants aged 16 or 20 months which assessed their ability to generalize psychological properties to the appropriate animate domain (e.g. people versus animals). At 72 months of age, these participants then returned to the laboratory to complete a battery of ToM tasks as well as an animacy task designed to measure their understanding of the essential properties between living and non-living kinds.

Interestingly, an association was found in Experiment 1 between the ability to categorize objects into animate and inanimate domains in infancy and later ToM knowledge at preschool age. In particular, infants' understanding that animals are more appropriate than vehicles for the purpose of enacting motion and sensory activities was related to their later knowledge of false-belief (considered the cornerstone of ToM) at preschool age. As well, the hypothesis that naïve biology may have its roots in an earlier understanding of the differences between animates and inanimates was also supported by the finding that infants' conceptual knowledge of animates and inanimates in infancy was linked to later knowledge of the concept of animacy at preschool age, providing much needed insight into the roots of naïve biology in infancy. Another noteworthy result was the presence of a concurrent relationship between preschoolers' understanding of animacy and sentiency and their knowledge of ToM. It would appear that children's reasoning about psychological phenomena, particularly mental states such as desires and beliefs, is linked to their understanding of animacy and sentiency during the preschool years. This finding expands upon the notion that children's biological framework may not be completely distinct from their psychological framework at preschool age, but rather the two may be linked by the understanding of people as causal and purposeful agents.

Unexpectedly, the findings of Experiment 1 were not replicated in Experiment 2. It is important to note, however, that infants' understanding of the A-I distinction was not assessed in this second study. Rather, infant's ability to generalize motion and sensory properties across a broad animate domain (i.e., to animals and people) was evaluated. Contrary to initial expectations, this early conceptual knowledge of the animate domain was not longitudinally associated with either ToM or knowledge of animacy at preschool age. It is also quite surprising that infants' preference for the person over the animal to imitate sensory events as an early measure of ToM ability was not linked to later ToM knowledge. As well, the modest concurrent correlations between ToM and knowledge of living and non-living kinds contributes to the possibility that the infancy and the preschool tasks employed in this study were likely tapping into different abilities such that continuity between these two time points was obscured. Despite the limited findings of Experiment 2, the overall findings of this paper contribute significantly to the literature on infants' early cognitive development. Specifically, this paper provides preliminary evidence that a) the A-I distinction in infancy may be a precursor ability to later knowledge of both ToM and naïve biology and b) children's biological knowledge system is related to their psychological one.

In the second paper (Frenkiel-Fishman, Poulin-Dubois, Rostad & Fombonne, submitted), the interface between naïve psychology and naïve biology was further explored by testing a population of autistic children. The demonstrated finding reported in the first paper of this thesis of a relationship between naïve psychology and naïve biology in typically developing children begs the question of whether a similar relationship between the two naïve theories is present in autistic children as well. Research demonstrating deficits in ToM reasoning in autistic individuals abound (e.g., Baron-Cohen & Goodhart, 1994; Happé 1995; Leslie & Frith 1988; Perner et al. 1989; Yirmiya et al., 1998). What remains unknown, in light of the evidence presented thus far of a link between naïve psychology and biology, is whether autistic children might also demonstrate a deficit in naïve biology. Evidence of a deficit in the realm of naïve biology in addition to that of naïve psychology among autistic individuals would theoretically support the proposed notion that the ability to perceive social information is related to the processing of biological motion. Therefore, the goal of the second paper was to examine whether young autistic children are impaired in their ability to form an A-I distinction. A sequential touching task was administered to a group of young typically developing children (Experiment 1) and autistic children (Experiment 2). The results showed that 18-month-old typically developing children successfully categorized at the domain level, as evidenced by their sequential touching of items from the same animate and inanimate categories. In contrast, the autistic children were impaired in their ability to categorize at the domain-level, though they did successfully categorize at the global-level. Overall, these data suggest that while the autistic children did not demonstrate knowledge of the broad animate domain, representative of categorization at the highest level of inclusiveness, their ability to form global categories can be interpreted as indicative of an ability to detect biological features in order to differentiate animate from inanimate categories. Furthermore, preliminary evidence suggests that autistic children's conceptual category acquisition follows the same developmental pattern as that of typically developing children, specifically that of a global-to-basic level categorization.

Contributions to the literature

Taken as a whole, the current dissertation helped further identify the developmental trend of children's knowledge of both naïve psychology and naïve biology, and shed light on the social information processing impairment in ASD by examining autistic children's acquisition of various levels of conceptual categories. The first paper represents an important contribution to the scientific research on children's developmental understanding of the mind. Until recently, the work on children's knowledge of mental states has tended to focus almost exclusively on the changes that occur between three and four years of age, with a great deal less consideration given to the early precursors of ToM in infancy. However, more recent investigations suggest that the extent of infants' and toddlers' knowledge has largely been underestimated and have provided evidence of early understanding of mental states in preverbal infants. The findings from our longitudinal studies have added to this emerging field by strengthening the notion that infants possess some rudimentary understanding of mental state reasoning much earlier than has traditionally been expected. We have successfully demonstrated that between 18 and 20 months of age infants are already aware that animals and not vehicles play the role of agents in motion and sensory events and that this awareness is related to their later understanding of false-belief at preschool age. This finding has certainly strengthened and extended the hypothesis that there is continuity in the development of naïve theories (Charman et al., 2000; Olineck & Poulin-Dubois, 2005, 2007) by establishing a link between the early understanding of biological differences between animate and inanimates in infancy and later knowledge of false belief.

Beyond this, the originality of this work is in its demonstration of an interdependence of knowledge, both longitudinally and concurrently, between naïve biology (i.e. animacy knowledge) and naïve psychology (false-belief understanding). To date, there is a considerable dearth of studies that have addressed the interface between these two different domains of thought. Our findings support the proposed relation between animacy and later ToM and are the first of their kind to demonstrate a link between these two types of naïve theories. Comparative studies across these domains, such as those of this dissertation, contradict the long-standing assumption among some researchers that psychological and biological cognitive domains function independently of one another (e.g. Inagaki & Hatano, 1993). Previous research has often treated the presence of knowledge of the mind as independent of knowledge of the natural world

(Binnie & Williams, 2002; Coley, 1995; Wellman & Gelman, 1992). Of course, one of the difficulties in opposing this position has been methodological in nature, with the challenge of devising tasks that assess equivalent levels of understanding across both domains. Our use of age-appropriate tasks that measure animacy as well as ToM in both infancy and preschool age is an added strength of the current thesis that further enables us to substantiate the proposed claim that psychological and biological reasoning are intertwined.

The current studies also expand upon existing knowledge of theories of ToM development in childhood. A central focus of research within the field of ToM concerns whether ToM is best conceptualized as a single unitary construct or, rather, one which differentiates into separate abilities. Consequently, a number of different theories have been put forth to account for the nature and development of ToM. One theory contends that an innate module for ToM exists. This 'Theory of Mind Module' hypothesis assumes that ToM derives from a specific module which instantaneously processes information about attended actions, considers those actions to be intentional, and thus automatically generates the relevant mental states for those actions. According to this modularity account, conceptual change does not take place during the infancy to preschool years. Rather, ToM develops as a result of the maturing process of the module itself (Baron-Cohen, 1995; Leslie, Friedman, & German, 2004; Scholl & Leslie, 2001). Evidence in support of this modularity hypothesis for ToM development is taken from the case of Autism. Seeing as people with autism are specifically impaired in their understanding of persons as psychological beings and that a ToM deficiency seems to be unique to autism, the assumption is that a biological, brain basis for ToM by way of a module must exist.

An alternative account to the modularity hypothesis posits that the nature and development of ToM is best understood as an everyday, naïve *theory* of the mind and of people as psychological beings. In this sense, ToM development proceeds by way of the creation, modification, and ultimately the replacement of preceding theories of the mind with more consistent ones which children have formulated as a result of evidence acquired through their interactions and experiences with people. This sequence of reformulation and subsequent replacement of theories is thought to be the result of general inferential mechanisms, and not a single unitary construct as the modularity account contends. Recent research has even provided evidence of a consistent developmental pattern in children's understanding of the mind, notably in false-belief performance, across various countries and task manipulations (Callaghan et. al., 2005; Wellman, Cross, & Watson, 2001). Furthermore, rather than being accounted for by an innate module which undergoes a maturation process, this "Theory Theory" account views the development of ToM as the result of conceptual changes in children's understanding of the mind which occur during the fundamental developmental years (Gopnik & Wellman, 1994; Wellman, 1992; Wellman & Gelman, 1998). Indeed, a multitude of studies have corroborated this approach as a means of explaining children's developing understanding of the social (Gopnik, 1993; Wellman, 1992), physical (Smith, Carey, and Wiser, 1985) and biological world (Carey, 1985; Gelman & Wellman, 1991).

The results of the current thesis are in favor of this theory theory hypothesis as well. Based on this naïve theories approach of how children view the world, developmental continuity in children's understanding of psychological and biological phenomena between the infancy and preschool years would be expected. Our finding that the A-I distinction in infancy was related to later knowledge of false-belief at preschool age supports the notion that children's interactions with people and explorations of the world around them contribute to their development of ToM. Our observed developmental continuity between infants' knowledge of animates and inanimates in infancy and later knowledge of the concept of animacy at preschool age further substantiates the theory theory account of ToM development.

Future Directions

No doubt, a number of limitations of the current thesis should be taken into consideration. The sample size in both of our longitudinal studies was relatively small. While it is well known that longitudinal studies inherently have a higher attrition rate than non-longitudinal ones, these small sample sizes may have inevitably obscured the relationship between a potential precursor (i.e. knowledge of animacy) and later abilities. Future studies should endeavor to assess a larger sample of participants at infancy so that sufficient statistical power remains to allow for the detection of a developmental trajectory, despite the attrition rate. That said, while the results of the second longitudinal study were less conclusive than the first longitudinal study, it is important to keep in mind that taken together, the results of both studies indicate that knowledge of animacy in young children may be linked to ToM ability at preschool age. This relevant finding ought to be replicated with a larger sample size in order to further identify the trajectories involved in children's ToM development.

Future research should also assess the ability to infer a wider range of psychological attributes to people in infancy (beyond looking into a mirror and answering a telephone) as a measure of infants' early ability to infer psychological properties exclusively to people. Perhaps then, more conclusive evidence can be found of a developmental continuity between infants' rudimentary understanding of the mind and later, more developed, ToM knowledge. While there is mounting evidence to support the notion that ToM gradually develops through a series of steps and that continuity exists between infants' elementary understanding of the human mind and later ToM ability (Poulin-Dubois, Brooker, & Chow, 2009; Sodian, in press), subsequent research that systematically follows children's increasing knowledge of animacy and sentiency from infancy to the preschool years would certainly strengthen the continuity hypothesis.

Another important avenue for future research is to further explore the roots of naïve biology in infancy. Inquiries into the origins of naïve biology are in stark contrast to what is happening in the field of naïve psychology where a growing number of research efforts are being devoted to studying children's early knowledge of the mind. While the A-I distinction in infancy was linked to later knowledge of animacy at preschool age in Experiment 1 of our first study, we failed to find a similar relationship between infants' ability to generalize motion properties across a broad animate domain and a more developed understanding of living and non-living kinds at preschool age in Experiment 2. It may be that the task employed in Experiment 2 did not properly assess preschooler's biological understanding such that continuity between early knowledge of animacy and later naïve biology could be detected. It would be interesting to explore whether other measures of preschooler's knowledge of conceptual categories of living and non-living kinds are linked to an earlier knowledge of the A-I distinction. Perhaps tasks that assess preschoolers' understanding that animals and artifacts have different internal parts (Gelman & Wellman, 1991; Simons & Keil, 1995) or tasks that assess whether preschoolers recognize that animate beings, in contrast to artifacts, grow larger over time (Rosengren, Gelman, Kalish, & McCormick, 1991) may be better measures of children's biological understanding.

Similarly, new tasks need to be devised to test biological understanding in infancy. An understanding of the biology of different species entails an understanding of differing properties of those species. Motion is critical in the early understanding of the differences between animate and inanimate objects. As such, tasks designed to measure infants' understanding of unique properties specific to animate objects (such as motion) are needed. One idea may be to examine whether infants understand that different motion properties are specific to different types of objects (animate versus inanimate) in the world. A generalized imitation task in which both animate motion (self-propelled motion) and inanimate motion (i.e. causal motion) were assessed may provide a better measure of the A-I distinction in infancy. Alternatively, a violation of expectancy task, a common experimental paradigm used in tests of naïve psychology, could be employed. This task requires the child to anticipate the behaviour of a person with a false belief. Studies using this particular methodology have shown that very young infants are aware of a character's false belief as evidenced by their increased looking time at a particular scene that is incongruent with the character's beliefs than at a scene that matches the character's beliefs (Onishi & Baillargeon, 2005; Surian, Caldi, & Sperber, 2007). This experimental procedure can be adapted to measure infants' understanding that certain motion trajectories are incongruent with specific object types. An increase in the infant's attention to an event that contravenes an expectancy of animate versus inanimate motion may be another way to assess biological understanding in infancy. While the extent to which such a task measures a deep level of understanding is debatable in light of the fact that no active behavioral response is elicited (Poulin-et al., 2009), it may nonetheless provide an index of infants' early appreciation that animate objects have different biological properties than inanimate objects. The use of these different infancy and preschool age tasks may enable continuity between early knowledge of animacy and later naïve biology to be better detected. The relationship between naïve biology and naïve psychology is an important one and the current dissertation represents an initial step in clarifying and outlining the progression of this relationship.

Over the years, research has sought to determine whether specific cognitive deficits can account for the unique symptoms of autism. More specifically, a large focus has been placed on the hypothesis that a difficulty in the ability to recognize people as psychological beings, otherwise known as ToM, is specific to autism. Granted, a deficit in ToM is not the sole cognitive impairment in autism. In particular, current conceptualizations of the neuropsychological impairments in autism also include weak central coherence (Frith & Happé, 1994; Shah & Frith, 1983), executive system dysfunction (Hill, 2004; Pennington & Ozonoff, 1996) and medial temporal lobe deficits (Hetzler & Griffin, 1981). Notwithstanding the contributions of these other theories of the causes of autism, the ToM deficit hypothesis has greatly increased our understanding of the disorder and has highlighted the need for tasks that tap into autism-specific deficits early on. In light of the evidence we presented in our first paper that the A-I distinction in infancy may be a precursor to later ToM knowledge, the question of whether a relationship between naïve biology and naïve psychology exists in autism is especially relevant. As such, in our second paper, we sought to explore whether young autistic children are capable of categorizing animate and inanimate objects at a domain-general level.

The ToM hypothesis of autism has focused predominantly on deficits in the realm of mental state reasoning. However, the ability to interact in a social manner, including the ability to process emotional and perceptual information, starts long before ToM skills are evident in typically developing children (Tager-Flusberg, 2007). Seeing as A-I distinction is a significant milestone in early *typical* cognitive development, we were interested in determining whether this accomplishment is present in autism as well. The results of this study indicated that autistic children are indeed capable of categorizing at a global (e.g. animals vs. vehicles), albeit not at a domain (e.g. animates vs. inanimates) level. This finding is promising and suggests that the detection of biological features is not completely impaired in individuals with ASD. However, it is important to bear in mind that our task was a sequential touching one and did not *explicitly* assess the ability to use biological motion to form conceptual categories of animates and inanimates. If the ability to process motion properties indeed serves as a precursor to later social development as suggested by Rutherford, Pennington and Rogers (2006), then a task better suited to measure biological motion might be more appropriate for addressing autistic children's knowledge of animacy. Further, if a deficit does indeed exist in the ability to form an A-I distinction among children with ASD, then potential tasks that assess the ability to form conceptual categories of animates and inanimates might be beneficial in the early detection of autism.

One possibility may be to utilize a generalized imitation task as was done in the first paper of this dissertation. Autistic children's ability to generalize target properties after having seen the target actions being modeled might be a more meaningful measure of their animacy understanding than the sequence in which they touch objects. While controversy exists concerning the presence and extent of an imitation deficit in autism, this is in large part due to the range of experimental methodologies employed across studies of imitation in autism as well as differing operational definitions of imitation (Sevlever & Gillis, 2010). The advantage of using a generalized imitation task with autistic children is its use of specific prompting strategies, direct instruction, and modeling to elicit a response. Beadle-Brown & Whiten (2004), for instance, investigated whether autistic individuals showed a deficit in imitation ability using an elicited imitation task. The authors tested nine different categories of actions, including both symbolic actions (e.g., stirring an imaginary spoon in bowl) and non-symbolic actions with objects (e.g., building a brick tower). While the authors reported a trend showing that children with mild to moderate intellectual disability as well as typically developing children were better able to imitate symbolic actions with objects than were children with autism, this result was not statistically significant. Overall, the authors did not find a general or autism-specific imitation deficit when elicited imitation was employed. However, a number of limitations in this study, including small sample sizes and ceiling effects for some or all groups on the different actions performed, make it difficult to draw clear conclusions from this study. Nevertheless, the use of a generalized imitation task with autistic children might be advisable especially in light of intervention efforts showing that autistic children benefit from observational learning and typical instruction (Ledford, Gast, Luscre, & Ayres, 2008; Tekin-Iftar & Birkan, 2010). The use of a generalized imitation task may therefore not only better assess autistic children's ability to use biological motion to form an A-I distinction, but can potentially be adapted as a screening tool.

Overall, the series of experiments in this thesis helped to clarify both the nature and development of precursors of ToM in infancy. Specifically, we successfully filled a gap in our current knowledge of precursors of both naïve psychology and naïve biology by revealing how the A-I distinction in infancy is related to later ToM and Animacy concepts. As well, this thesis contributed to our understanding of deficits in ASD and attempted to lay the groundwork for future explorations of tasks that can detect signs and symptoms of autism at an earlier age.

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Appendix A

Sample Recruitment Letter for Experiment 1 (Chapter 2)

November 21st 2005

Dear Parents,

We would like to thank you for your past interest and participation in our research program a few years ago and we wish to invite you to return to our laboratory for another study on cognitive development. As you may recall, your child participated in one of our research projects when they were approximately 16-months-old. In this study, we were interested in examining whether infants understand that certain objects belong to the same group (e.g., cow and cat are both animals). To test whether infants had this ability, the experimenter modeled events which were exclusively done by people (e.g., answering a telephone) or done by both animals and people (e.g., moving up a set of stairs). We found that infants have a broad understanding of these categories by this young age.

We are now eager to learn whether there is a link between infants' imitative abilities and their later understanding (as preschoolers) of people's behavior. As such, we invite you to return to our laboratory with your child. Your child will be presented with a series of stories and asked to guess what a puppet knows or prefers on the basis of these stories. We will also be investigating whether children's vocabulary is related to their behavior during these tasks. To measure vocabulary, children will be asked to point to pictures that correspond to different words.

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

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

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


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

_______________________
Sarah Frenkiel-Fishman, M.A.
Ph.D. Candidate
Department of Psychology

Appendix B

Sample Parent Consent form for Experiment 1 and 2 (Chapter 2)

Parental Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois and Sarah Frenkiel-Fishman of Concordia University.

## A. PURPOSE

I have been informed that the purpose of the research is to examine preschoolers' understanding of other people's desires and beliefs.

## B. PROCEDURES

In this study, your child will be told five stories and asked to guess what a puppet knows or prefers on the basis of these stories. For example, your child will be shown a box of Smarties, asked what they think is inside, and then shown that the box actually contains crayons. Once the crayons are back in the box, your child will be asked to predict what a puppet thinks is inside the box. We will also measure your child's vocabulary by using a standard vocabulary test, which involves pointing to pictures of different words. You will be able to watch your child at all times through a one-way mirror throughout the entire session. We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality. That means that the researcher will not reveal your child's identity in any written or oral reports about this study. Your child will be assigned a coded number, and that number will be used on all materials collected in this study. As well, because we are only interested in comparing children's understanding as a function of age, no individual scores will be provided following participation. The entire session is expected to last approximately one hour.

## C. RISKS AND BENEFITS

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

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

## D. CONDITIONS OF PARTICIPATION

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

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

MY CHILD'S NAME (please print) ___________________________________

MY NAME (please print) __________________________________________

SIGNATURE __________________________ DATE ___________________

WITNESSED BY _______________________ DATE ___________________

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


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Participant # ____________

Researcher: __________________

Appendix C

Participant Information Form in Experiment 1 & 2 (Chapter 2)

**Participant Information**

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

Infant's last name: ______________________ Gender: ______________________

Language(s) spoken at home: ______________________

Mother's first name: ______________________ Father's first name: ___________________

Mother's maiden name: __________________ Father's last name: ___________________

Address: _____________________________ Telephone #: ___________________home

_____________________________ __________________________ work mom

Postal Code: __________________________ __________________________ work dad

e-mail: _______________________________

Mother's occupation: ______________________ Father's occupation: ___________________

Mother's education (highest level attained): ______________________

Father's education (highest level attained): ______________________

Mother's marital status: _______________ Father's marital status: ________________

*Please answer the following general information questions about your child:*

Birth weight: Length of pregnancy: weeks

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

Number of siblings:

Were there any complications during the pregnancy?

Has your child had any major medical problems?

Does your child have any hearing or vision problems?

Participant#: _____________ Researcher: _____________

Appendix D

Protocol for ToM Battery in Experiment 1 & 2 (Chapter 2)

**TOM Scale: False Belief Tasks**

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

*The child is shown a smarties box and asked what he/she thinks the box contains.*

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

*If the child responds with candies or smarties, then proceed to the next step*

*If the child does not spontaneous respond in this way, the experimenter should prompt the child by pointing to the picture of smarties*

**Experimenter:** "Look at these! Do you know what these are?"

*When the child responds, the experimenter should repeat the previous question:*

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

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

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

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

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

**Experimenter:** "Okay, what's really inside the smarties box?"

**Experimenter:** "**What did you think was inside this box when I first showed it to you? Did you think there were crayons inside it or did you think there were Smarties inside it**" *(Self belief question)*

*The experimenter then introduces a puppet and the child is then asked the 2nd test question:*

**Experimenter:** "Look! This is Jennifer/Peter, and he/she has never ever seen inside this smarties box. When I show this box to Jennifer/Peter, what will he/she think is inside, before he/she opens it? Smarties or crayons? (*Other belief question)*

*[These 2 test questions are scored as separate false belief tasks).*

***Materials:***
*Smarties Box, Crayons, Picture of story character*

## TOM Scale: Desire Task

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

*The child is shown a toy figure of a child and a sheet of paper with pictures of a carrot and a cookie on it. The child is then presented with a story in which the child story character's favourite food is a carrot:*

**Experimenter:** "Here's Melissa/Charlie. Melissa/Charlie's favourite food is a carrot. It's snack time now so Charlie wants a snack to eat.

**Experimenter:** "Can you remember what Melissa/Charlie's favourite food is?" *(Memory control question)*

**Experimenter:** "It's snack time now, which snack do you think Melissa/Charlie would want to eat? A carrot or a cookie?" *(Test question)*

**Experimenter:** "Which is your favourite of these two foods: carrots or cookies?" *(Control question)*

> *[Note: The forced choice option (carrots and cookies) should be counterbalanced across children.]*

**Experimenter:** "Which snack would you want to eat?" *(Control question)*

> ***These control questions are included to ensure that the child is not simply reporting his/her own mental state, when asked about those of the story character.*

***Materials:***
*Picture of carrot and cookie*
*Picture of story character*

**TOM Scale: Emotion Task**

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

*The child is shown a girl/boy puppet and a sheet of paper with a picture of a pair of black socks on it.*

For a girl — **Experimenter:** "Here's Linda. It's Linda's birthday soon. Linda really wants a pair of black socks for her birthday. At her birthday party, Linda opened her birthday present and inside was a Barbie doll.

For a boy — **Experimenter:** "Here's Matt. It's Matt's birthday soon. Matt really wants a pair of black socks for his birthday. At his birthday party, Matt opened his birthday present and inside was a toy racing car

**Experimenter:** "What did Linda/Matt want for her/his birthday*?" (Memory control question)*

*Child is then presented with an illustration of the story character with a happy face and an illustration of the story character with a sad face and asked the test question:*

**Experimenter:** "How do you think Linda/Matt felt when s/he saw the [Barbie doll/toy racing car]? Would s/he be happy or sad? *[Test question]*

*[Note: the presentation of the forced choice options (happy and sad) should be counterbalanced across children]*

**Experimenter:** "Which would you want for your birthday? Black socks or a Barbie doll/toy racing car? *[Control question #1]*

**Experimenter:** "How would you feel if you got a Barbie doll/toy racing car for your birthday? Would you feel happy or sad?" *[Control question #2]*

> ***These control questions are included to ensure that the child is not simply reporting his/her own mental state, when asked about those of the story character.*

***Materials:***
*Picture of Barbie/Socks or Car/Socks*
*Picture of Character with neutral face*
*Picture of story character with different emotions*

## Four Sweets Task

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

*The child is presented with four chocolate bar wrappers secured to a piece of card and asked:*

**Experimenter: "**Which chocolate bar do you like the most out of these four?"

**Experimenter:** "Here's Tammy/Mark. [POINT TO FACE] Tammy/Mark went shopping his her/his mother to buy groceries for dinner. Tammy/Mark was so well-behaved in the grocery store that his/her mother allowed her/him to choose a treat out of four different chocolate bars."

*The child is then presented with a picture that has the story character's face in the centre, with four chocolate bar wrappers secured in each corner. The story character is smiling and looking at one of the chocolate bars. The experimenter always selects versions of the picture in which the story character is looking at a chocolate bar that is different from the child's previously stated preference.*

**Experimenter:** "Can you tell me, looking at Tammy/Mark's **<u>FACE</u>**, which chocolate bar s/he wanted?"

***GRANDMOTHER VERSION***
**Experimenter:** "Now, I know you said that ________ is your favourite chocolate bar, but can you tell me what your 2nd favourite is?".

*The child is presented with four chocolate bar wrappers secured to a piece of car and asked:*

**Experimenter:** "The next day, Tammy/Mark went shopping her/his grandmother to buy groceries for dinner. Tammy/Mark was so well-behaved in the grocery store that his/her grandmother allowed her/him to choose a treat out of four different chocolate bars."

**Experimenter:** "Can you tell me, looking at this picture, which chocolate bar Tammy/Mark wanted this time?"

***Materials:***
*Picture of 4 chocolate bars*
*Picture of 4 chocolate bars with face gazing*
*Picture of story character*

# Appendix E

## Protocol for Animacy-Acceptability Task in Experiment 1 (Chapter 2)

## ANIMACY-ACCEPTABILITY TASK - RANDOM ORDER #1

**4 PRACTICE QUESTIONS:**

1. The ballerina drank the dream
2. The cow drove the car home.
3. The teacher picked up the cloud.
4. The giraffe played tennis.

**RANDOMIZED QUESTIONS:**

24. The **chair** knows that the snow is falling outside.
13. The **elephant** wants all the peanuts from the zoo keeper.
1. The **woman** knows that there is a car in the driveway.
29. The **pencil** ate the piece of cake on the table.
10. The **dog** knows where to hide its bone in the yard.
11. The **monkey** wants to climb the trees in the zoo.
26. The **telephone** slept on the table in the bedroom.
20. The **radio** wants the clown to throw his ball.
9. The **rabbit** knows that there are carrots in the kitchen.
18. The **tree** wants the babysitter to fix the toy.
12. The **cat** wants to catch the mouse under the table.
23. The **bicycle** knows that there is a fish in the pond.
31. The **shoe** ate the bread in the toaster.
8. The **father** slept in the chair by the fireplace.
30. The **clock** ate the fruit from the lunchbox.
15. The **horse** slept on straw in the field.
19. The **ball** wants the band to play some music.
4. The **man** wants the policeman to find the money.
28. The **book** slept on the shelf next to the movies.
14. The **tiger** wants to run fast after the deer in the jungle.
25. The **eraser** slept on the carpet under the couch.
21. The **flower** knows that there is a penny on the ground.
5. The **girl** ate chocolate chip cookies for desert.
16. The **bear** slept under a tree in the woods.
17. The **tulip** wants the lady to go shopping.
2. The **boy** knows that the TV in his room was a gift.
6. The **mother** ate breakfast before she woke up her children.
27. The **fridge** slept in the kitchen next to the oven.
7. The **child** slept in the bed next to her sister.
3. The **baby** wants his mother to give him milk.
32. The **schoolbag** ate chocolate cake for desert.
22. The **rose** knows who painted the picture on the wall.

Appendix F

Coding Form for ToM battery in Experiment 1 and 2 (Chapter 2)

**THEORY OF MIND SCALE – CODING SHEET – ORDER A**

| | |
|---|---|
| **Participant #:** | |
| **Language:** | **Sex:** M F |
| **D.O.B:** (mm/dd/yy) | **Age in Decimals** |

| | |
|---|---|
| **Date Coded:** | |
| **Coded by:** | |
| **Task Order:** | **ToM Order:** 1 2 3 4 |

| **False Belief Task** | **Circle Child's Response** | | **Correct Response** |
|---|---|---|---|
| What do you think is inside this box? *(control question)* | Smarties | Pens | |
| Can you remember what's really inside this box? *(control question)* | Smarties | Pens | |
| What did you think was inside this box when I first showed it to you? *(self's belief) (test question #1)* | Smarties | Pens | |
| When I show this box to __________ tonight, what will he/she think is inside, before he/she opens it? *(other's belief) (test question #2)* | Smarties | Pens | |
| ***The self & other's belief questions are scored separately*** **Score (max = 2)** | | | |

**Comments:**

| **Desire Task** | **Circle Child's Response** | | **Correct Response** |
|---|---|---|---|
| Can you remember what Charlie's favourite food is?" *(memory control question)* | carrot | cookie | |
| Which snack do you think Charlie would want to eat? Raw vegetables or lollipops?" *(test question)* | carrot | cookie | |
| Which is your favourite of these two foods: vegetables or lollipops?" *(control question)* | carrot | cookie | |
| Which snack would you want to eat?" *(control question)* | carrot | cookie | |
| **Score (max = 1)** | | | |

**Comments:**

| Emotion Task | Circle Child's Response | | Correct Response |
|---|---|---|---|
| What did Linda/Matt want for her/his birthday? *(memory control question)* | Socks | Barbie/Car | |
| How do you think Linda/Matt felt when s/he saw the [Barbie doll/toy racing car]? Would s/he be happy or sad? *[test question]* | Happy | Sad | |
| Which would you want for your birthday? Black socks or a Barbie doll/toy racing car? *[control question #1]* | Black socks | Barbie doll/ toy racing car | |
| How would you feel if you got a Barbie doll/toy racing car for your birthday? Would you feel happy or sad?" *[Control question #2]* | Happy | Sad | |
| | | **Score (max = 1)** | |

**Comments:** ______________________________

______________________________

______________________________

______________________________

| Four Sweets Task | Child's Response | Correct Response |
|---|---|---|
| ***(mother version)*** ***(chocolate target: ______________)*** | | |
| Which chocolate bar do you like the most out of these four? | | |
| Can you tell me, looking at this picture, which chocolate bar Tammy/Mark wanted? | | |
| ***(grandmother version) (chocolate target: ______________)*** | | |
| Which chocolate bar do you like 2nd most out of these four? | | |
| Can you tell me, looking at this picture, which chocolate bar Tammy/Mark wanted? | | |
| | **Score (max = 1)** | |

**Comments:** ______________________________

______________________________

______________________________

______________________________

| **Total TOM Scale Score** |
|---|
| ____ / 5 |

**PPVT SCORE:**

Appendix G

Coding Form for Animacy-Acceptability Task in Experiment 1 (Chapter 2)

## ANIMACY –ACCEPTABILITY TASK (ENGLISH)
## QUASI RANDOM ORDER #1

| | |
|---|---|
| **Participant #:** | |
| **Language:** | **Sex:** M F |
| **D.O.B:** (mm/dd/yy) | **Age in Decimals** |

| | |
|---|---|
| **Date Coded:** | |
| **Coded by:** | |
| **Task Order:** | |

*Experimenter: "Let's play a game. Here's Jennifer (Puppet). Jennifer is going to say some sentences and I want you to tell me whether the sentence is OK or whether it's Silly. OK? Let's try a few."*

*(N.B.: A * indicates un-acceptable sentences – ask "why is it silly" for a total of 8 unacceptable sentences)*

**PRACTICE QUESTIONS**

| | | | |
|---|---|---|---|
| A | The ballerina drinks her dreams | **OK** | **SILLY** |
| B | The cow drives the car home | **OK** | **SILLY** |
| C | The teacher picks up the cloud | **OK** | **SILLY** |
| D | The giraffe plays tennis | **OK** | **SILLY** |

**TEST QUESTIONS**

| | | | |
|---|---|---|---|
| *24 | The **chair** knows that the snow is falling outside | **OK** | **SILLY** |
| 13 | The **elephant** eats all the peanuts in the zoo | **OK** | **SILLY** |
| 1 | The **woman** knows that there is a car in the driveway | **OK** | **SILLY** |
| *29 | The **pencil** eats the piece of cake on the table | **OK** | **SILLY** |
| 10 | The **dog** knows where to hide its bone in the yard | **OK** | **SILLY** |
| 11 | The **monkey** wants to climb the trees in the zoo | **OK** | **SILLY** |
| *26 | The **telephone** sleeps on the table in the bedroom | **OK** | **SILLY** |
| *20 | The **radio** wants the clown to throw his ball | **OK** | **SILLY** |
| 9 | The **rabbit** knows that there are carrots in the kitchen | **OK** | **SILLY** |
| *18 | The **tree** wants the babysitter to fix the toy | **OK** | **SILLY** |
| 12 | The **cat** wants to catch the mouse under the table | **OK** | **SILLY** |

| | | | |
|---|---|---|---|
| *23 | The **bicycle** knows that there is a fish in the pond | **OK** | **SILLY** |
| *31 | The **shoe** eats the bread in the toaster | **OK** | **SILLY** |
| 8 | The **father** slept in the chair by the fireplace | **OK** | **SILLY** |
| *30 | The **clock** eats the fruit from the lunchbox | **OK** | **SILLY** |
| 15 | The **horse** sleeps on straw in the field | **OK** | **SILLY** |
| *19 | The **ball** wants the band to play some music | **OK** | **SILLY** |
| 4 | The **man** wants the policeman to find the money | **OK** | **SILLY** |
| *28 | The **book** sleeps on the shelf next to the movies | **OK** | **SILLY** |
| 14 | The **tiger** eats the deer in the jungle | **OK** | **SILLY** |
| *25 | The **eraser** sleeps on the carpet under the couch | **OK** | **SILLY** |
| *21 | The **flower** knows that there is a penny on the ground | **OK** | **SILLY** |
| 5 | The **girl** eats chocolate chip cookies for desert | **OK** | **SILLY** |
| 16 | The **bear** sleeps under a tree in the woods | **OK** | **SILLY** |
| *17 | The **tulip** wants the lady to go shopping | **OK** | **SILLY** |
| 2 | The **boy** knows that the TV in his room was a gift | **OK** | **SILLY** |
| 6 | The **mother** eats breakfast before she wakes up her children | **OK** | **SILLY** |
| *27 | The **fridge** sleeps in the kitchen next to the oven | **OK** | **SILLY** |
| 7 | The **child** sleeps in the bed next to her sister | **OK** | **SILLY** |
| 3 | The **baby** wants his mother to give him milk | **OK** | **SILLY** |
| *32 | The **schoolbag** eats chocolate cake for desert | **OK** | **SILLY** |
| *22 | The **rose** knows who painted the picture on the wall | **OK** | **SILLY** |
| | **TOTAL** | | |

Appendix H

Sample recruitment letter for Experiment 2 (Chapter 2)

January 25th 2006

Dear Parents,

We would like to thank you for your past interest and participation in our research program a few years ago and we wish to invite you to return to our laboratory for another study on cognitive development. As you may recall, your child participated in one of our research projects when she or he was approximately 16-or 20-months-old. In this study, we were interested in examining whether infants have acquired categories such as animals or people. To test whether infants have this ability, the experimenter modelled events which were either animal-like and people-like (motion events such as moving up a set of stairs) or exclusively people-like (sensory events such as answering a telephone). The experimenter modelled these motion events and sensory events using a monkey doll. After the modelling, infants were provided with the opportunity to imitate these events with a choice of two new toys: a new animal and a new person.

We found that at 16 months of age infants consider people and animals as members of the same domain, and thus, have developed a broad category of animates by that age. The follow-up study with 20-month-olds indicated that by that age, infants begin to attribute sensory properties exclusively to people as opposed to animals. We are pleased to inform you that the results of this study will be published this year in the Journal of Cognition and Development.

We are now eager to learn whether there is a link between infants' imitative abilities and their later understanding of people's behavior around the age of 6 years. As such, we invite you to return to our laboratory with your child. Your child will be presented with a series of stories and asked to guess what a story character knows or prefers on the basis of these stories. We will also be investigating whether children's vocabulary is related to their behavior during these tasks. To measure vocabulary, children will be asked to point to pictures that correspond to different words.

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

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

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

Sincerely yours,

| | |
|---|---|
| Diane Poulin-Dubois, Ph.D. | Sarah Frenkiel-Fishman, M.A. |
| Professor | Ph.D. Candidate |
| Department of Psychology | Department of Psychology |

Appendix I

Protocol/Coding form for Animacy Task for Experiment 2 (Chapter 2)

**Psyc-Biol Task (ENGLISH)**
**RANDOM ORDER #1**

| Participant #: | | |
|---|---|---|
| Language: | | Sex: M F |
| D.O.B: (mm/dd/yy) | Age in Decimals | |

| Test Date: | |
|---|---|
| Coded by: | |
| Task Order: | |

*Experimenter: "Let's play a game. I'm going to ask you questions and you have to answer yes or no. OK?"*

| | TEST QUESTIONS | | |
|---|---|---|---|
| 8.a | Does a stone have eyes? | YES | NO |
| 8.b | Does a stone have bones? | YES | NO |
| 8.c | Does a stone breathe? | YES | NO |
| 8.d | Does a stone grow bigger and bigger? | YES | NO |
| 8.e | Can a stone feel pain if we prick it with a needle? | YES | NO |
| 8.f | Can a stone move to where it wants to by itself? | YES | NO |
| 8.g | Can a stone think? | YES | NO |
| 8.h | Can a stone want something? | YES | NO |
| 8.i | Can a stone know something? | YES | NO |
| 8.j | Can a stone feel happy? | YES | NO |
| 8.k | Can a stone speak to a person? | YES | NO |
| 8.l | Does a stone have a heart? | YES | NO |
| 5.a | Does a grasshopper have eyes? | YES | NO |
| 5.b | Does a grasshopper have bones? | YES | NO |
| 5.c | Does a grasshopper breathe? | YES | NO |
| 5.d | Does a grasshopper grow bigger and bigger? | YES | NO |
| 5.e | Can a grasshopper feel pain if we prick it with a needle? | YES | NO |
| 5.f | Can a grasshopper move to where it wants to by itself? | YES | NO |
| 5.g | Can a grasshopper think? | YES | NO |
| 5.h | Can a grasshopper want something? | YES | NO |
| 5.i | Can a grasshopper know something? | YES | NO |
| 5.j | Can a grasshopper feel happy? | YES | NO |
| 5.k | Can a grasshopper speak to a person? | YES | NO |
| 5.l | Does a grasshopper have a heart? | YES | NO |
| 2.a | Does a rabbit have eyes? | YES | NO |
| 2.b | Does a rabbit have bones? | YES | NO |

| | | | |
|---|---|---|---|
| 2.c | Does a rabbit breathe? | **YES** | **NO** |
| 2.d | Does a rabbit grow bigger and bigger? | **YES** | **NO** |
| 2.e | Can a rabbit feel pain if we prick it with a needle? | **YES** | **NO** |
| 2.f | Can a rabbit move to where it wants to by itself? | **YES** | **NO** |
| 2.g | Can a rabbit think? | **YES** | **NO** |
| 2.h | Can a rabbit want something? | **YES** | **NO** |
| 2.i | Can a rabbit know something? | **YES** | **NO** |
| 2.j | Can a rabbit feel happy? | **YES** | **NO** |
| 2.k | Can a rabbit speak to a person? | **YES** | **NO** |
| 2.l | Does a rabbit have a heart? | **YES** | **NO** |
| 3.a | Does a pigeon have eyes? | **YES** | **NO** |
| 3.b | Does a pigeon have bones? | **YES** | **NO** |
| 3.c | Does a pigeon breathe? | **YES** | **NO** |
| 3.d | Does a pigeon grow bigger and bigger? | **YES** | **NO** |
| 3.e | Can a pigeon feel pain if we prick it with a needle? | **YES** | **NO** |
| 3.f | Can a pigeon move to where it wants to by itself? | **YES** | **NO** |
| 3.g | Can a pigeon think? | **YES** | **NO** |
| 3.h | Can a pigeon want something? | **YES** | **NO** |
| 3.i | Can a pigeon know something? | **YES** | **NO** |
| 3.j | Can a pigeon feel happy? | **YES** | **NO** |
| 3.k | Can a pigeon speak to a person? | **YES** | **NO** |
| 3.l | Does a pigeon have a heart? | **YES** | **NO** |
| 6.a | Does a tulip have eyes? | **YES** | **NO** |
| 6.b | Does a tulip have bones? | **YES** | **NO** |
| 6.c | Does a tulip breathe? | **YES** | **NO** |
| 6.d | Does a tulip grow bigger and bigger? | **YES** | **NO** |
| 6.e | Can a tulip feel pain if we prick it with a needle? | **YES** | **NO** |
| 6.f | Can a tulip move to where it wants to by itself? | **YES** | **NO** |
| 6.g | Can a tulip think? | **YES** | **NO** |
| 6.h | Can a tulip want something? | **YES** | **NO** |
| 6.i | Can a tulip know something? | **YES** | **NO** |
| 6.j | Can a tulip feel happy? | **YES** | **NO** |
| 6.k | Can a tulip speak to a person? | **YES** | **NO** |
| 6.l | Does a tulip have a heart? | **YES** | **NO** |
| 4.a | Does a fish have eyes? | **YES** | **NO** |
| 4.b | Does a fish have bones? | **YES** | **NO** |
| 4.c | Does a fish breathe? | **YES** | **NO** |
| 4.d | Does a fish grow bigger and bigger? | **YES** | **NO** |
| 4.e | Can a fish feel pain if we prick it with a needle? | **YES** | **NO** |
| 4.f | Can a fish move to where it wants to by itself? | **YES** | **NO** |
| 4.g | Can a fish think? | **YES** | **NO** |
| 4.h | Can a fish want something? | **YES** | **NO** |
| 4.i | Can a fish know something? | **YES** | **NO** |
| 4.j | Can a fish feel happy? | **YES** | **NO** |
| 4.k | Can a fish speak to a person? | **YES** | **NO** |

| | | | |
|---|---|---|---|
| 4.l | Does a fish have a heart? | **YES** | **NO** |
| 1.a | Does a person have eyes? | **YES** | **NO** |
| 1.b | Does a person have bones? | **YES** | **NO** |
| 1.c | Does a person breathe? | **YES** | **NO** |
| 1.d | Does a person grow bigger and bigger? | **YES** | **NO** |
| 1.e | Can a person feel pain if we prick him/her with a needle? | **YES** | **NO** |
| 1.f | Can a person move by him/herself? | **YES** | **NO** |
| 1.g | Can a person think? | **YES** | **NO** |
| 1.h | Can a person want something? | **YES** | **NO** |
| 1.i | Can a person know something? | **YES** | **NO** |
| 1.j | Can a person feel happy? | **YES** | **NO** |
| 1.k | Can a person speak to another person? | **YES** | **NO** |
| 1.l | Does a person have a heart? | **YES** | **NO** |
| 7.a | Does a tree have eyes? | **YES** | **NO** |
| 7.b | Does a tree have bones? | **YES** | **NO** |
| 7.c | Does a tree breathe? | **YES** | **NO** |
| 7.d | Does a tree grow bigger and bigger? | **YES** | **NO** |
| 7.e | Can a tree feel pain if we prick it with a needle? | **YES** | **NO** |
| 7.f | Can a tree move to where it wants to by itself? | **YES** | **NO** |
| 7.g | Can a tree think? | **YES** | **NO** |
| 7.h | Can a tree want something? | **YES** | **NO** |
| 7.i | Can a tree know something? | **YES** | **NO** |
| 7.j | Can a tree feel happy? | **YES** | **NO** |
| 7.k | Can a tree speak to a person? | **YES** | **NO** |
| 7.l | Does a tree have a heart? | **YES** | **NO** |

Appendix J

Sample Recruitment Letter for Experiment 1 (Chapter 3)

Recruitment Letter

Dear parents,

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

In the present study, we are examining infants' understanding of living beings and inanimate objects. Your child will be presented with a selection of toys to play with for two minutes to assess his or her categorization skills. During this task, your child will be sitting in a child seat and you will be seated directly behind. A video camera will be used to record the tasks, so that we can measure how long your child plays with the toys.

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

For the purposes of this study, we are looking for infants who are ___ months of age, who hear English or French spoken at home, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Kristin Rostad at 514-848-2424, ext. 2279 or Dr. Diane Poulin-Dubois at 514-848-2424, ext. 2219. We will try to contact you by telephone within a few days of your receipt of this letter.

Thank you for your interest and collaboration.

____________________

Diane Poulin-Dubois, Ph.D.
Professor
Psychology Department
diane.poulindubois@concordia.ca

____________________

Kristin Rostad, B.A.
M.A. Student
Psychology Department
k_rostad@alcor.concordia.ca

Appendix K

Sample Parent Consent Form for Experiment 1 (Chapter 3)

Informed Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois and Kristin Rostad of Concordia University.

**A. PURPOSE**

I have been informed that the purpose of the research is to examine how infants understand living beings and inanimate objects.

**B. PROCEDURES**

The present investigation involves examining how infants categorize objects in the world around them, and the strategies they are most likely to use. Your child will be presented with a series of small toys from different categories of objects and we will measure how long he/she touches each of them. During this task, your child will be sitting in a child seat and you will be seated directly behind. We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality. That means that the researcher will not reveal your child's identity in any written or oral reports about this study. Your child will be assigned a coded number, and that number will be used on all data collected in this study.

**C. RISKS AND BENEFITS**

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

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

**D. CONDITIONS OF PARTICIPATION**

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

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

MY CHILD'S NAME (please print) ______________________________________

MY NAME (please print) ______________________________________________

SIGNATURE ____________________________ DATE ____________________

WITNESSED BY _________________________ DATE ____________________

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


________________________
Diane Poulin-Dubois, Ph.D.
Professor
Department of Psychology
514-848-2424 ext. 2219
diane.poulindubois@concordia.ca

________________________
Kristin Rostad, B.A.
M.A. Student
Department of Psychology
514-848-2424 ext. 2279
k_rostad@alcor.concordia.ca

Appendix L

Administration Protocol for Sequential Touching Task in Experiment 1 & 2

(Chapter 3)

## SEQUENTIAL TOUCHING TASK – ADMINISTRATION PROTOCAL FOR AUTISTIC SAMPLE

**EXPLAINING THE RATIONALE OF THE STUDY TO THE PARENTS**

- We will be presenting your child with some toys to play with
- We would like to see what they do with these toys.

**TESTING SET-UP**

- Child is seated in a chair (or on parent's lap).
- If child is seated in a chair, the parent is seated behind the child.
- The experimenter is seated in a chair across the table from the child, so that the experimenter is facing the child.
- All testing session are video-taped.

**PARENT INSTRUCTION**

During the study your child will definitely turn around to look at you, What I will ask you to do…

- to remain neutral
- OK to smile
- OK to touch your child
- OK turn him/her back around
- Do NOT touch any particular item
- Do NOT label any of the items
- Do NOT talk to your child
- OK to pick up or catch a toy if it falls on the floor
- ❖ Important not to influence child in any way, children are very good at picking up cues

**ADMINISTRATION OF SEQUENTIAL TOUCHING TASK:**

- Present all 8 toys on a tray in a random fashion
- Allow child to play with toys for about 2 minutes – or until s/he touches all the toys
- Place tray in the middle of the child & make sure it is within reach
- Say "Look at these…. These are for you to play with."

➢ If child turns around to look at the parent: redirect the child's attention by saying:
*"CHILD'S NAME Look at the toys!"*

➢ If child ignores some of the toys (i.e. does not touch the toys), highlight the toys (wave hand in circle above the toys- without pointing at any specific toy) and say:
*"CHILD'S NAME Look at these!"*

➢ Experimenter does not say anything else

➢ If the child drops an object or an object is out of reach
→ Unobtrusively place object within reach

**DEBRIEFING AFTER THE STUDY**

- Children presented with a series of toys such as these are likely to touch the objects in a systematic manner. Often children touch the items from a given category in sequence.
- This phenomenon has been observed in many children, across different studies, so it doesn't seem to be just random.
- The way they touch the items seems to be giving us information about what they have noticed. Children are noticing that these 2 items are related, or part of the same "category."
- This gives us important information about how children understand objects in the world around them. At this age, children seem to have developed a sophisticated understanding of the world around them. However, they do not yet have the words to be able to tell us what it is that they know. A task like this allows us to gain insight into children's knowledge about the world around them.

Appendix M

Coding Protocol for Sequential Touching Task in Experiment 1 & 2

(Chapter 3)

## CODING PROTOCOL FOR SEQUENTIAL TOUCHING TASK

The following rules should record the sequence of the toys touched.

- Begin coding (and time counting) once the child touches a toy and all the toys are present on the table.
- Record the toys touched from each category according to the sequence in which they were touched.

e.g.:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Animal | A | A | | A | A | | | |
| Vehicle | | | V | | | V | V | V |

This means two animals were touched, then a vehicle, than two animals again, then three vehicles (or two vehicles since the first and last vehicle can be the same toy: This is explained later)

- Each trial last 2 ½ minutes (Use the timer on the VCR to record this time because trials can go over).
- At the end of the trial record the total number of touches, and the mean run length (MRL)- combining both animal and vehicle categories

e.g.:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Touches | MRL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | A | | A | A | | | | A | | A | A | A | A | 14 | 2.00 |
| | | V | | | V | V | V | | V | | | | | | |

- MRL is the mean number of objects belonging to the same category which a child touches in one sequence. To determine the MRL: calculate how many times the object (from the same category) is touched in a row for each instance, e.g.: the child touched the animal 2 times, 2 times, once, 4 times. The child also touched the vehicle once, then 3 times, then once. Then, divide the number of instances the sequential touching took place across the entire task (e.g.: 7 times) Therefore,
    - MRL: (2+2+1+4+1+3+1)/7 = 2.00 This is the total MRL for the entire sequential touching trial.

**There are more specific rules to deal with other events that may occur during the session.**

- If an interval of more than 10 seconds occurs between two touches, a break in sequence should be recorded. This is designated by a double line in the grid. Ultimately, this will affect the mean run length since the sequence of touching is interrupted by a delay. E.g.: Using the same example as above, lets say there is a 30 second delay between two of the touches with the animal:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Touches | MRL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | A | | A | A | | | | A | | A | A | A | A | 14 | 1.75 |
| | | V | | | V | V | V | | V | | | | | | |

- If the experimenter or the parent draws the child's attention to a certain toy or a toy falls, and the child touches it immediately, this should not be counted as part of the sequence. Record this touch with an X.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A | | | A | A | | | | 1A, 1V, 2A, 3V |
| | V | ⊗ | | | V | V | V | |

- If the child touches the same toy twice or more in succession (without a 10 second break) it is counted as the same touch.
  (Do not record it twice. However, if a child touches a toy, 10s elapse, and s/he touches the toy again, this is counted as a new touch.
- If the child focuses on and touches a new toy, while still holding another object, record a touch for the new object
- If the child holds an object in his hand, and plays with other objects with the other hand, and then returns attention to the original object. This is counted as a single touch – the first time the child touches it, even though the child has returned attention to it later.
- An object can be coded more than once, if a child: **touches the object, then lets it go, then touches a different object, then touches the original object again.**
- If two objects are touched at the same time, record them both and put a circle around them.
  - If two objects are from the same category, this is counted as one touch.
  - If two objects from different categories are touched, this is not counted at all (record them with a circle around it)
- Touch: Physical contact with an object using finger, hand, or other object.
  - The touch must be deemed as intentional and the infant has to be focused on the object (Oakes et al., 1996).
  - Accidental touches (brushing against a toy while reaching for another) or touching an object without looking at it, does not qualify as a "touch"
- Subjects who ignore one of the categories completely (0 touches for the category) are EXCLUDED

Appendix N

Coding Form for Sequential Touching Task in Experiment 1 & 2

(Chapter 3)

**SEQUENTIAL TOUCHING TASK – AUTISM STUDY**

Name: ___________________________ Subject Number: __________ Sex: F M
Tested by: ________________

Date Tested: ___________________Date of Birth: ________________ Coder: ______________________

Lap Baby: Y N Parental Interference: _______________________________________________________________

START: ______________________STOP: ______________________

Comments:_________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_______________

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle | | | | | | | | | | | | | | | | | | | | |
| Animal | | | | | | | | | | | | | | | | | | | | |

| | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | Touches | Runs | MRL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle | | | | | | | | | | | | | | | | | | |
| Animal | | | | | | | | | | | | | | | | | | |