IMITATIVE ABILITY IN PRESCHOOL AGE CHILDREN WITH AUTISM IN THE PRESENCE OF ODOR

By

CAROLINE NELL COFFIELD

A Dissertation submitted to the

Graduate School-New Brunswick

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Graduate Program in Psychology

written under the direction of

Jeannette Haviland-Jones

and approved by

____

____

____

____

New Brunswick, New Jersey

May 2010

ABSTRACT OF THE DISSERTATION

Imitative ability in preschool age children with autism in the presence of odor

CAROLINE NELL COFFIELD

Dissertation Director:

Jeannette Haviland-Jones

Individuals with Autism Spectrum Disorder (ASD) are generally thought to be impaired in the ability to imitate, but the causal processes responsible for this deficit are not well understood. Different theoretical perspectives offer different insights as to which behaviors are most difficult for individuals with ASD to imitate and why. This study investigated the imitative ability of five 3-5 year old children with ASD and thirty-two of their typically developing peers of the same ages on several categories of behavior thought to be difficult for individuals with ASD to imitate, including emotional expressions, motor behaviors, and sequences. Imitation was assessed twice using a newly refined imitation test, with approximately 1 week between visits. Imitation was scored for each component of the action imitated for each repetition. Overall, there were differences in imitative ability due to age for every category measured and due to diagnosis for nearly every category, with larger effect sizes for age. When all categories were measured at once, there was a significant age X diagnosis interaction; performance of older children with ASD approximated that of older typically developing children but younger children with ASD were consistently the worst imitators. Odor effects were modest. In general, odor affected imitative performance differently for older and younger children, with younger children benefiting more from odor when imitating more complex tasks. Looking behavior also varied according to age and diagnosis, with younger children with ASD appearing disorganized in their strategy for attending during the imitation task. The other groups appeared similar, with older children with ASD approximating the looking behavior of younger typically developing children. Looking behavior and imitation performance were related. It is suggested that the study of imitation should be broad enough to speak to multiple theoretical perspectives so as to create a more unified description of imitative abilities in individuals with ASD.

Acknowledgement

I would like to thank Jeannette Haviland-Jones for her support and her constant and continued belief in me. Our student-mentor relationship began by change, but endured because of mutual respect and similar research interests. It has been a thoroughly enjoyable and genuinely profitable experience to have worked with Jeannette these many years. I thank Judith Hudson and Sandra Harris for wonderful feedback and encouragement throughout my graduate career. I am grateful to Linda Reddy for agreeing to be on the committee for this dissertation, and for the clinical insights she contributed to the project.

Many thanks to Eilyn Aguilar and Andrea Rydel, who contributed hours of data entry and coding time. Without you, this project would never have been finished. Thanks also to Adam, Andrew, Rachel and Rebecca for their valuable contributions to this study. Special thanks to Estelle Mayhew, who gave moral support and sage advice over the years. This experience would not have been as much fun or as easy to bear without you "in my corner".

Thanks to Deborah Spitalnik for her kind guidance and upbeat realism throughout this process. I look forward to continuing to work with you and to learn from you.

To my family and friends, Greg especially, thank you for bearing with me and for allowing me to dedicate myself to this dissertation so that it might reach an end. I love you all and cannot imagine having gone through this without your encouragement.

This dissertation is dedicated to all the families who so graciously gave of their time to participate in this study. Thank you!

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

Autism Spectrum Disorder (ASD) is a much studied pervasive developmental disorder that is still not well understood. ASD is also a growing area of interest and research funding opportunities, due, in part, to the prevalence of the disorder. When last measured in 2006, 1 in every 110 eight-year-old children was reported to have ASD, an increase of 57% in the 10 study sites since 2002 (Autism and Developmental Disabilities Monitoring Network Surveillance, 2009). This is an alarming increase, making ASD a research priority and an urgent public health concern.

Individuals with ASD can have a number of social and communicative impairments that vary in severity from individual to individual. The cause of ASD is unknown and there is no cure for ASD; however, intervention at as early age as possible produces great benefit for these children in terms of acquisition of cognitive and communicative abilities (Rogers, 1996). For this reason, many researchers are now examining early behaviors that appear to be impaired in individuals with ASD. One such behavior is imitation. Imitation has been found to be impaired in children and adolescents with ASD in a number of studies (e.g. Smith & Bryson, 1994; Stone, Ousley, & Littleford, 1997; Williams et al., 2001) however this finding has not been undisputed.

The study of imitation includes investigation of a number of categories of behavior including emotional expression, simple motor behaviors, and complex sequences of actions. It appears that imitation skills may vary across different experimental tasks as well as categories of behavior. Findings differ with respect to (potentially) impaired categories of behavior and they differ across individuals with ASD. Often features of the task and comparison group composition are cited as contributing to the different findings. Imitation can occur spontaneously or be elicited, as in many experimental contexts, and is largely not a unitary skill. These challenges to the study of imitation will be addressed in depth in Chapter 2 of this paper.

Chapter 1 will present a review of several theories that attempt to explain the underlying deficits associated with ASD, theories that consider imitation to be an important predictor. Imitation is an important learning mechanism, especially in early development, and has obvious links to language learning and to the development of many important social skills (Meltzoff & Moore, 1999; Rogers & Williams, 2006; Smith & Bryson, 1994). All of the theories that will be reviewed consider impairments in imitative ability to be a defining feature of ASD, yet no theory is comprehensive or without criticism. One of the main differences in many of these theoretical perspectives is what they stress as the core problem for individuals with ASD; does it lie in the cognitive domain, the social/emotional domain, or is it a combination of both?

A less prominent consideration, often absent from much of the research around deficits in imitation in individuals with ASD, is that of social motivation. Given the tendency for individuals with ASD to be uninterested, or at least inattentive and more likely to look away, avoiding eye contact or gazing at one's interaction partner during social exchanges, (Berger, 2006; Hobson & Hobson, 2007) it remains possible that these children are not interested in engaging in imitative, social behaviors or that they are not motivated to behave by the typical social rewards that often occur in response to imitation (Ingersoll, Schreibman, & Tran, 2003). The lack of social motivation may account for some of the apparent differences in cognitive imitative abilities and may be somewhat distinct from social/emotional skills. Providing a supportive environment for testing may be essential to optimizing attention and mood processes that help enhance task engagement and performance. Recent research suggests that the sensory environment could be managed to promote performance (Ingersoll, Schreibman, & Tran, 2003). For example, Ingersoll et al. reported more imitation in a group of children with ASD when the objects they were manipulating lit up and produced sounds than when the objects did not give this sensory output (2003). The possibility that a supportive sensory environment can enhance social motivation will also be addressed in Chapter 3, followed by an introduction to a potential social motivation intervention – pleasant odor.

Interestingly, the chemosensory environment may be a more important contributor to performance and emotion regulation than has been previously recognized. There is a body of research that suggests that odor, and the olfactory system, one of the earliest sensory systems to develop and become functional in neonates (Schaal, Marlier, & Soussignan, 2000), may unconsciously influence behavior, affecting emotion regulation, thereby making individuals more adaptive/more attentive in a mildly stressful situation (Coffield, Mayhew, Haviland-Jones, & Walker-Andrews, in preparation). Further, work on social motivation suggests that although children with ASD are not as motivated by social rewards as are their typically developing peers, they are motivated by sensory feedback (Ingersoll, Schreibman, & Tran, 2003). Thus, an intervention employing odor might affect social motivation, enabling children to attend to the presented behaviors longer, to be more responsive to the olfactory sensory reward the imitative context offers, or, at least, to remain in the experimental context longer than they otherwise would. All of these possible effects will be measured in the current study. Direction and duration of gaze will be measured for the entire duration of every visit;

imitative response will be measured after every presentation of every behavior, and total time spent in the experimental context will also be recorded.

The current study will investigate imitative behavior in 3-5 year old children diagnosed and in treatment programs for ASD and in 3-5 year old typically developing children. Each child will complete the experiment twice, in the presence of a low level of a pleasant odor once and with no odor once, order counterbalanced. The task will take place in a tent constructed for this purpose, in the child's home, with the child's mother participating in the task with her child. The experimenter will be observing and recording behavior, but not interacting in the task. The task will be constructed so as to address lingering questions left unanswered by previous theories, while also testing the mild odor intervention. These are the questions to be addressed in the following study. (1) Might imitation be a delayed development, but not an altogether absent ability, in children with ASD? (2) Is imitation of emotion, specifically, deficient in individuals with ASD? (3) Are sequences or patterns of behavior more difficult to imitate than simple behaviors with fewer components? (4) Can a pleasant odor be used to motivate children, especially those children who are most vulnerable (younger children or children with ASD) so as to improve their performance?

Chapter 1: Imitation and Autism Spectrum Disorder

According to the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), Autism Spectrum Disorder (ASD) is a pervasive developmental disorder characterized by any combination of (a) impairments in social interaction; (b) impairments in communication; (c) restricted repetitive and stereotyped patterns of behavior, interests, and activities; and (d) delays in either social interaction, language as used in social communication, or symbolic and imaginative play manifested before age 3 (2004). More specifically, the impairments in social interaction associated with ASD might take the form of (a) impairments in the use of multiple non-verbal behaviors such as eye contact, facial expressions and gestures; (b) failure to develop appropriate peer relationships; (c) lack of spontaneous seeking to share enjoyment, interests or achievements with other people; and (d) lack of social or emotional reciprocity (or using others only as a means to an end rather than a true interaction partner) (APA, 2004). There is striking diversity among individuals with autism in terms of how impaired they may be in any or all of these areas. Classic autism, Asperger's syndrome and Pervasive Developmental Disorder Not Otherwise Specified (PDDNOS), the diagnosises that make up the autism spectrum, are all considered to be types of pervasive developmental disorders because they all involve severe impairments in more than one area of development (Graziano, 2002).

Recent research has supported the hypothesis that impairments of social cognition and imitation are a primary feature of ASD (Rogers and Pennington, 1991; Rogers & Williams, 2006; Williams, Whiten, Suddendorf, & Perrett, 2001). To understand how the specific impairments associated with autism develop and begin to shape behavior and experience we must understand how imitation develops typically as well as be able to identify gaps or disruptions in the development of imitation skills in children with ASD (Cicchetti & Beeghly, 1990; Sigman, 1989). Further, we must scrutinize the categories of behavior examined, the measures and tasks used to study imitative behavior, and the ages at which specific impairments have been detected to best identify and understand such impairments.

Imitation occurs when “one individual voluntarily reproduces behavior as observed in another who acts as the model for the form of a behavior” (Butterworth, 1999, p. 65). Imitation is a much studied topic in developmental psychology and in a variety of other disciplines because of the implications the act of imitation holds for human learning and development. For example, Piaget emphasized the role of imitation as an antecedent to the development of symbolic thought and language (Smith & Bryson, 1994). Meltzoff and Moore (1999) stress the importance of imitation as a primary means by which human infants come to understand the concepts of self, other, and the relationship between the two. Likewise, Rogers and Williams (2006) emphasize the importance of imitation to the development of social cognition, “the ability to learn about the world indirectly, from others, and to profit from each others experiences” (p.ix). Social cognition is an integral process that allows humans to learn and experience the world above and beyond their own direct perspectives. Indeed, imitation is an integral skill that serves two distinct functions: a learning function, through which infants acquire new skills and knowledge, and a social function, through which infants engage in social and emotional exchanges with others (Ingersoll, 2008). Problems in imitation are thought to lead to the development of some characteristic deficits associated with autism, such as impaired language ability and/or other social communicative abilities (Meltzoff & Gopnik, 1993; Rogers & Pennington, 1991).

There has been a great deal of research that has examined whether impairments of imitative ability exist in children with ASD (e.g. Charman & Baron-Cohen, 1994; Curcio, 1978; DeMyer, Alpern, Barton, DeMyer, Churchill, Hingtgen, Bryson, Pontius, & Kimberlin, 1978; Loveland, Tunali-Kotoski, Pearson, Brelsford, Ortegon & Chen, 1994; Smith & Bryson, 1994; Williams, Whitten, Suddendorf, and Perrett, 2001). Most of this work supports the hypothesis that there is a general imitation deficit in children with ASD (Loveland et al., 1994; Rogers & Pennington, 1991; Smith & Bryson, 1994; Williams et al., 2001). Rogers and Pennington (1991) reviewed 8 of the early studies that looked for deficits in imitation in children with ASD. All but one of the studies they reviewed reported deficits in imitation in children with ASD. DeMyer and colleagues compared 12 children with autism and schizophrenia, with a mean chronological age of 67 months, to 12 children with intellectual disability, with a mean chronological age of 72 months on measures of body imitation, motor-object imitation, and spontaneous object use. They found that the children with autism were significantly worse at imitating body movements and actions on objects than controls (1972). However, there were no differences for non-imitated purposeful object acts, making an explanation of motor deficits in the experimental group unlikely (Rogers & Pennington, 1991). More recently, Hertzig, Snow and Sherman (1989) found that 18 lower functioning, verbal individuals with autism (average age 18 years, 6 months) were poorer at imitation of motor and symbolic actions, particularly when an action was primarily affective, than were 14 IQ matched individuals with intellectual disability (average age 18 years, 5 months) and 19 language matched typically developing preschoolers (mean age 4 years, 11 months).

Not every study of imitation in children with ASD has found differences in this group. For example, Charman and Baron-Cohen (1994) tested 20 children with autism and 23 chronological and verbal mental age-matched children between the ages of 5 and 19 years old. They tested the children on procedural imitation using a task modeled on that of Meltzoff and gestural imitation using actions based on the Uzgiris and Hunt Sensorimotor Scales (1975). They found no differences between the groups on either type of imitation. Ceiling performance on the tasks by both groups was suggested as a possible explanation for this finding. The authors further suggest that perhaps imitation in children with autism is delayed, but does eventually develop, partially explaining the inconsistent findings around imitation in children with autism (Charman & Baron-Cohen, 1994). Morgan and colleagues similarly failed to find differences in imitative abilities between 10 eight-year-old children with autism, 10 eight-year-old children with mental retardation, and 10 three-year-old typically developing children tested using the Dunst revision of the Uzgiris and Hunt sensorimotor scales (Morgan, Cutler, Coplin & Rodrigue, 1989). Methodological issues including ceiling effects, small sample size, and inappropriate selection of control groups are often pointed to as possible reasons for not finding group differences in imitative ability. However, most studies of imitative ability in ASD, including those that have found deficits, have (a) lacked sufficient and comprehensive controls, (b) examined only one or two specific categories of imitative ability, with few numbers of behaviors tested within each category, (c) used small sample sizes, and (d) used a global and subjective coding system (Beadle-Brown & Whiten, 2004). The current study will address several of these issues through the use of a more comprehensive test for imitation that incorporates many behaviors previously reported to be impaired in individuals with ASD. This test will be scored using an objective coding system that identifies which components of each behavior the child imitated and which the child did not, a novel approach to assessing imitation that should provide more detailed information about what aspects of the behaviors might be challenging or not.

Deficits in imitation are often considered a distinctive feature of ASD (Rogers, Hepburn, Stackhouse, & Wehner, 2003) and are increasingly coming to be seen as a potential early predictor for later diagnosis (Perra, Williams, Whiten, Fraser, Benzie & Perrett, 2008). At the same time, deficits in imitation provide important insight into the origins of the disorder itself (Rogers & Williams, 2006). Thus, more clearly defining deficits in social skills, like that of imitation, will ultimately help to better understand the underlying neurological origin(s) of ASD and will point to innovative and meaningful treatments for the disorder (Stone, Ousley, & Littleford, 1997). However, one of the major difficulties to fully understanding the deficits of imitation often reported in individuals with ASD is the disparate nature of the findings. These differences in findings are most probably due to the theoretical perspectives various researchers bring to the topic, which necessarily limits which behavior they study and can speak about. More important for clearly speaking to underlying neurological origins of ASD and for suggesting potentially meaningful treatments, is a comprehensive and clear picture of where impairments do and do not lie in ASD. Thus it is essential to begin to combine categories of behaviors and theoretical perspectives and to test in a more all-encompassing fashion.

Theories of imitative deficits in autism

There are several models that attempt to explain the imitative deficits seen in individuals with autism, and these models differ in their conceptualization of the major system or pathway of impairment. Several of the major theories will be examined in this review, using illustrative research examples from each to explicate the possible origin of the imitative deficits. Recent research into the mirror neuron phenomenon will then be examined as a possible causal mechanism for the imitation deficits in ASD.

The Theory of Mind hypothesis. One of the most recognized theories of deficit in social skills related to autism is that of the Theory of Mind hypothesis. This hypothesis suggests that the imitative deficit seen in children with autism is indicative of emerging problems with Theory of Mind, another oft observed problem associated with autism (Meltzoff & Gopnik, 1993; Rogers & Pennington, 1991). These authors believe that children with autism have difficulty recognizing that "I am like other" and thus cannot grasp the relationship between his/her own, inner states and the outer, visible world of others (Charman & Baron-Cohen, 1994). Gopnik and Meltzoff (1993), through the study of typically developing young children and neonates, posit that the basis for understanding the thoughts and feelings of another person comes from making connections between one's own activities and the activities of one's interaction partner. Thus, the inability to imitate the actions of another may be linked to abnormalities in the development of Theory of Mind. Essentially, Theory of Mind is the ability to understand that other people think, feel, want or believe things (Baron-Cohen, Leslie, & Frith, 1985) and to know "how other people's minds are similar to or different from your own mind" (Meltzoff & Gopnik, 1993, p.336). Having a Theory of Mind allows a person to understand what another believes and, thus, to predict how that other will behave in a given situation.

Leslie suggests a modular explanation of deficits of Theory of Mind in autism (1987). He suggests that Theory of Mind is developed as innate meta-representational abilities mature. For Leslie, these abilities are present from birth, but mature and begin to function at appropriate times during development. In autism, the failure of a particular part of these meta-representational abilities to mature accounts for observed deficits. According to this perspective, there are innate restraints on the form of Theory of Mind; it is not as adaptable to new or contradictory information as is that suggested by Meltzoff and Gopnik.

Meltzoff and Gopnik posit that the ability to recognize that “I am like other” is an innate ability in typically developing children (1993). They cite evidence that neonates only a few hours old are able to imitate human facial displays (Meltzoff & Moore, 1999) as proof that these newborns perceive an act carried about by another person, recognize sameness between that person and himself, and are able to plan and carry out the motor plan required to reproduce that behavior. For Meltzoff and Gopnik, any deficit in Theory of Mind in children with autism is rooted in the absence of an innate understanding about the nature of persons, including the ability to link external behaviors with internal states (1993). For these researchers, this innate information may be adjusted as the child learns more about the world.

A third Theory of Mind (ToM) perspective is that of simulation. According to this perspective, “when typically developing individuals perceive another person in a certain situation, they will automatically and unconsciously project that perception back onto the observer's own motor, cognitive, and emotional representation in order to run an offline simulation" (Oberman & Ramachandran, 2007, p.310). The later ability to imitate the mental state of another might be learned through the course of first imitating the behaviors, expressions and postures of another. Exactly how this occurs, whether the process is unconscious or explicit and intentional, remains unclear. However, recent work has proposed that the mirror neuron system (see separate section below) might enable this simulation to occur, with this process of simulation being a crucial component to imitation and the development of a Theory of Mind (Oberman & Ramachandran, 2007).

For these authors and others who support a deficit in ToM in children with autism, imitation is seen as a precursor, an indicator, that these underlying abilities are askew in this population. Thus, if problems with imitation are predictive of deficits in ToM, and if deficits in ToM are a unique identifying trait of individuals with autism, then tests of imitation may become diagnostic.

To test for deficits in Theory of Mind in young children, researchers use a variety of tasks. One of the first tasks used to demonstrate lack of ToM is the false belief task (Wimmer & Perner, 1983). In this task, two dolls, Sally and Ann, are together in the same space. Sally puts an item in a basket and then leaves the room. While Sally is gone, Ann moves the item from the basket to a box. Then Sally comes back into the room. The belief test question, and thus the test for ToM, asks the participant where Sally will look for the item, in the basket or the box. If the participant can recognize that Sally does not know that the item was moved, he/she will say Sally will look in the basket. If the participant says she will look in the box, he/she has failed the false belief task; the participant is unable to view the situation from Sally's perspective and separate what she would know/think from reality. This task also features control questions that ask where the item is now and where the item used to be. If the participant correctly responds to these questions, it suggests that he understands that the item was moved after Sally left the room.

Baron-Cohen, Leslie and Frith performed one of the earliest studies using the false belief task with children with autism (1985). They compared performance on the false belief task among 20 eleven-year-old children with autism, 14 ten-year-old children with Down syndrome, and 27 typically developing four-year-olds. They intentionally included children with autism with a higher mental age than the children with Down syndrome to eliminate the potential for finding an effect due to intellectual disability alone. All children correctly answered the control questions. Children with Down syndrome and typically developing children passed the false belief question at similar rates, 85% and 86% respectively. Conversely, 80% of the children with autism failed the false belief question. The author's conclude that children with autism did not recognize the difference between their own knowledge and that of the doll (Sally).

These authors conducted a follow-up study of picture sequencing tasks with the same group of children to further test for ToM ability (Baron-Cohen, Leslie, & Frith, 1986). Picture sequences requiring mechanical (physical-causal relations), behavioral (people acting and/or interacting), and intentional understanding (consideration of mental state of protagonist) were used in this experiment. In order to successfully sequence the 4 pictures included in each type of sequence, participants had to draw upon one of the above kinds of reasoning ability. The authors again found that the children with autism had more difficulty correctly ordering pictures in the intentional understanding stories than they did in either of the other two conditions, and they had more difficulty relative to children with Down syndrome and typically developing children with this group of stories. Again, the authors suggest a specific impairment in Theory of Mind in children with autism. Findings of deficits in Theory of Mind have been replicated in several later studies (i.e. Baron-Cohen, 1989; Leslie & Frith, 1988) suggesting that ToM deficits are a core feature of autism (Ozonoff & Miller, 1995).

In a recent study, children with autism spectrum disorder, children with general developmental delay and typically developing children ages 6-15 years old were tested on tasks of imitation and Theory of Mind (false belief tasks) as part of a larger battery of tests administered (tests of dexterity, motor planning, and verbal skills) (Perra, Williams, Whiten, Fraser, Benzie, & Perrett, 2008). The authors applied discriminant function analyses to performance on the aforementioned tasks to determine which combinations of variables could most reliably discriminate individuals of the different groups, thereby predicting group membership. Two significant dimensions were found. First, the typically developing group and the group with general developmental delay differed on measures of dexterity and verbal ability. Once these differences were accounted for, the ASD group was distinguishable from the other two groups by differences in Theory of Mind and imitation task performance (Perra et al., 2008). The authors conclude that ToM performance was the best predictor for ASD group membership, but inclusion of imitation performance as a predictor significantly increased discrimination of groups. Thus, imitation seems to be related to ToM and perhaps, in conjunction with ToM performance, impairments in these abilities is specific to autism.

There are several critiques of the ToM hypothesis that suggest that it is not a comprehensive explanation for the deficits seen in autism. First, ToM is highly related to verbal memory (Buitelaar, van der Wees, Swaab-Barneveld, & van der Gaag, 1999; Hughes & Ensor, 2005) and therefore ToM indices might not always be free from confound. Furthermore, deficits of ToM are not unique to ASD (Holmes, 2002). Children with Specific Language Impairment, for example, exhibit impairments in Theory of Mind skills (Holmes, 2002). Further, children with autism become able to pass the false belief task when they are taught Theory of Mind skills, but this competency does not necessarily extend into real-life social situations (Ozonoff & Miller, 1995). After a four month long intervention designed to teach Theory of Mind skills, adolescent boys with autism demonstrated the ability to pass the false belief task. However, parent and teacher ratings of more generalized social interaction did not change from pre-test baseline scores. Nor did the post-test social interaction scores of the treatment group differ from those of the comparison group of same-aged boys with autism who did not receive the intervention.

Though not without its critics, the Theory of Mind hypothesis of autism, which views imitation as a developmental precursor to ToM, has been one of the primary explanations for the impairments of autism. New research findings continue to suggest that Theory of Mind is abnormal, at the least, in individuals with autism but a definitive explanatory pathway has yet to be presented.

Theory of Mind cannot be tested directly through tests of imitative ability, though the two abilities have been linked in prior studies. The current study will not be able to speak directly to this position since it will be a test of imitation. However, given the number of researchers who study ToM, albeit from slightly different perspectives, there is almost certainly a cognitive dimension to the impairments seen in ASD. ToM is presented in this review given its prominent position as an explanatory model for ASD and because it provides a cognitive account of the deficits of ASD that the subsequent theories will allude to or incorporate.

The Identification hypothesis. The interpersonal view of imitation emphasizes the engagement between partners in an interaction where both partners recognize that “I am like other”, and thus may share an understanding of their actions and of their situation (Uzgiris, 1999). Uzgiris (1999) further explains that this view stresses the joint construction of the interaction and the important role of communication to that exchange. The observation of reciprocal imitative exchanges between mothers and their infants further suggests the important social function of imitation. From this perspective, imitation is a form of social engagement that allows the partners involved in the interaction to create and define their social world (Uzgiris, 1999). As children develop, imitation may serve as a means for them to practice social interactions and to develop an understanding of social interactions more generally (Masur, 2006).

Work by Hobson has presented a complementary theory that seeks to explain many of the deficits seen in autism, including that in imitative ability. Hobson suggests that individuals with autism are unable to identify with others (Hobson & Hobson, 2007). By identify with others, the author means “An observer registers and assimilates another person’s bodily anchored psychological stance (whether in feeling or action or some other way of relating to the world), in such a way that the stance becomes a potential way of the observer relating to the world from his or her own position” (Hobson & Hobson, 2007, p. 411). Hobson suggests that this ability to identify with others is a crucial component of the ability to imitate another and to share an experience with another (Hobson & Hobson, 2007). In other words, Hobson suggests that individuals with autism have difficulty distinguishing people from things (Hobson, 1986) and therefore they are unable to appreciate that those people have thoughts, wishes, and intentions. Accordingly, individuals with autism have problems with perception and recognition of emotion as well as with developing reciprocal, affectively based relationships (Rogers & Pennington, 1991). Moreover, Hobson and Meyer (2006) suggest a developmental slant to the role of abnormal identification in worsening symptoms of autism. They suggest that if a child is unable to identify with another, then experience interacting with and learning from others will be abnormally and negatively affected as the child grows.

Hobson's theory is built upon studies of abnormalities in the perception of emotional expression of faces and parts of faces by individuals with autism (Hobson, Ouston & Lee, 1988; Langdell, 1978). Langdell (1978) examined the ability of two groups of children, younger children with a mean age of 10 years and older children with a mean age of 13.5 years, to recognize the face of a peer using isolated features (nose, mouth, eyes) and progressively revealing more of the face. Children with autism, typically developing children matched for chronological age, and children with developmental delay matched for mental age were included in the same sample. He found that younger children with autism were better at recognizing their peers using the lower region of the face (mouth and nose) whereas the other two groups were more accurate using the upper features of the face (brow and eyes). Older children with autism did not appear to rely on one facial area more than any other, but did make as many errors as the younger children with autism on recognizing peers from the lower facial region and as many errors as the other groups on the upper face condition. Langdell concludes that children with autism likely have a cognitive deficit that inhibits processing of nonverbal interpersonal communication (Langdell, 1978).

Further, work by Hobson indicates that individuals with autism, compared to individuals with intellectual disability and typically developing individuals, are impaired in their ability to “recognize how emotionally expressive faces, voices and gestures are coordinated with each other and with affect-inducing situations” (Hobson, Ouston, & Lee, 1989, p. 237). Hobson tested this ability in 23 fourteen-year-old children with autism, 23 typically developing seven-year-old children, and 11 fourteen-year-old children with intellectual disability. All children watched 10 second video clips of (1) bodily gestures of emotion (with the face of the actor obscured), (2) a blank screen with vocalizations thought to typically pair with the target emotions, and (3) contexts that would likely produce the target emotions. The children’s task was to select the appropriate drawing of a facial expression, from among the 5 in front of them, that goes with what they just saw. The autistic children were impaired in their ability to choose the matching faces for the gestures and contexts of emotion, and this ability was highly related to their mental age (Hobson, 1986). Hobson suggests that children with autism have difficulty recognizing how different expressions of the same emotion are related to each other, which might hinder their ability to understand the emotional states of others.

One very clever study examined the self-other body orientation of children with autism in the context of an interpersonal interaction. Twenty 12-year-old children with autism and twenty 12-year-old children with developmental delay were given the opportunity to select a sticker and were then told by the experimenter to put the sticker "here". As the experimenter said "here", she pointed to a location on her body. The experimenter then took a sticker for herself and asked the child where she should put her sticker. The goal of the task was for the child to indicate on his/her own body where the experimenter should place the sticker on herself. Compared to the children with developmental delay, children with autism were less likely to point to their own bodies to indicate where the experimenter should place the sticker. Hobson and Meyer interpret these results as further evidence of weak identification ability in children with autism (2005).

Recent work by Hobson and Lee (1999) and Hobson and Hobson (2007) suggests that children with autism are not motivated by the interpersonal engagement opportunity present in most imitative scenarios. Rather, they attend to or share during the encounter only minimally or moderately so as to be able to copy, but not to engage with the tester. Hobson and Lee tested 16 fourteen-year-old children with autism and 16 chronologically and verbally age matched children with developmental delay for their ability to imitate four novel actions on objects presented in two different "styles", either gently or harshly (1999). Both groups were able to imitate the basic actions, but children with autism were less likely to copy the "style" with which the action was modeled. Hobson and Hobson (2008) reproduced this finding using a similar testing procedure. Again, the authors speak to a difference (deficit) in motivation and ability to share experiences among individuals with autism as underlying many of the social abnormalities observed in this population.

Deficits in imitation of actions, such as non-affective motor behaviors, that do not require social understanding or social connection certainly limit the explanative value of the identification hypothesis (Smith & Bryson, 1998, Williams et al., 2004). Rogers and Pennington (1991) explain that the ability to imitate occurs earlier in the developmental trajectory than do the higher order social cognitive abilities to which Hobson attributes the deficits of imitation in autism. Further, abnormalities in perception of emotion are not unique to autism and have been reported in other clinical groups, including those with intellectual disability (Kasari, Mundy, Yirmiya & Sigman, 1990). Thus, while the affective hypothesis does address specific impairments observed in individuals with autism, it is probably not an exclusive or exhaustive explanation.

The affective hypothesis will be integrated into the current study in two ways. First, a behavior category of emotional expression to be imitated will be built into the study. This will directly test whether young children are able to imitate affective expressions and whether this differs from their ability to imitate simple motor behaviors or to manipulate objects within an imitative context, for example. Second, affective expressions will be included in more complex behavior sequences throughout the remaining categories of behavior (with the exception of the simple motor tasks), to examine whether children with ASD are able to attend to and replicate the affective component of a complex behavior with a goal that does not require the affective display. For example, to imitate the sequence of behavior, rub chin, rub head, rub chin, modeled while smiling, the sequence of rubs can be imitated successfully without the smile also being displayed. Of course, if any part of the sequence is equally likely to be absent, there would be no reason to surmise that emotional display was especially difficult to imitate, only that pattern sequencing was difficult to imitate. Again, one of the unique aspects of the scoring system to be used in the current study is that it allows for analysis of separate components of behavior sequences, so that an examination of affective behaviors and motor behaviors related to the sequence of action can be tested together as a whole, and separately. This is a more effective way to measure whether emotion makes the task more difficult, or to determine if the complex sequence of actions that comprise the task are difficult in and of themselves.

The interpersonal development hypothesis. Rogers and Pennington (1991) integrate deficits in emotion sharing, as put forth by Hobson, and deficits in Theory of Mind into a developmental model of autism based on the intersubjectivity paradigm proposed by Stern (1985). Along with imitation, which they view as an innate ability for infants, Rogers and Pennington say emotion sharing and Theory of Mind are primarily and specifically deficient in autism. All three of these abilities "appear to involve forming and coordinating specific social representations of self and other at increasingly complex levels via amodal or cross-modal representational processes that extract patterns of similarity between self and other" (Rogers & Pennington, 1991, p. 151). It is this process, forming and coordinating representations of self and other, which the authors believe is the central, causal deficit in autism. The results of this deficit, impaired imitation, affect sharing and theory of mind, and leave the child unable to access the social world or to understand the inner life of others via the usual methods. Rogers and Pennington propose a biologically based, developmental theory of autism: they see imitation, affect sharing and Theory of Mind as developing sequentially, and in the order listed, such that deficits in one ability will negatively influence the development of the next (1991). Further, given the developmental nature of their model, the authors predict the greatest imitative deficits for young children with autism, remaining open to the possibility that these individuals can learn to imitate; older children would be more likely to exhibit problems with Theory of Mind and language. Findings by Stone et al. support this claim as children with autism who were tested twice, with approximately 1 year between visits, showed improvements in motor skills (as assessed with the Motor Imitation Scale) between the age of 2 and 3 years (1997).

This intersubjectivity model of autism attempts to combine the earlier affective sharing hypothesis and the ToM hypothesis, while seeking to explain some of flaws of those previous theories. One of the main flaws in both hypotheses, as viewed by Rogers and Pennington, is that imitation abilities reported in neonates occur much earlier than the affective and cognitive developments that would be required for either of the previous hypotheses to be fully explanatory of such deficits. The authors do not discount either hypothesis, or the evidence supporting them, but rather suggest that neither is a comprehensive explanation. For example, they argue that there are affective abnormalities in autism. Yet, past research on perception of facial affect has produced somewhat mixed findings as to whether individuals with autism are deficient in this ability (Hertzig et al., 1989; Hobson, 1986; Rogers et al., 2003) or not (Braverman, Fein, Lucci & Waterhouse, 1989).

Recently, Rogers has restated her theoretical perspective (2003). Recent work by her group and others suggests that there may be more than one process responsible for imitative ability. For example, Stone, et al. (1997) found that imitation of actions with objects represents an independent dimension of imitative ability from imitation of body movements. Performance on these tasks by three-year-old children with autism, children with developmental delay, and typically developing children reveal poorer imitation of body movements (including oral-facial movements) than imitation of actions with objects. Further, these types of imitation were not correlated with each other, nor were they similarly correlated with the same developmental skills (i.e. expressive language and pretend play).

Rogers et al. (2003) performed a similar study of imitation in young three year olds. In this study, children with autism were significantly poorer imitators of novel actions on objects and oral-facial movements than both children with developmental delay and typically developing children. Correlations were found between severity of autistic symptoms and imitation score and between joint attention and imitation score, but imitation was not found to be related to other skills such as pretend play or social responsivity once developmental level was accounted for. This group's failure to replicate Stone et al.'s earlier findings is likely due to the different tasks used, both in terms of simplicity of the task (Stone's being more simplistic) and inclusion of a baseline condition in the Rogers et al. study to assure the child would not have produced the act without the behavioral model (Rogers et al., 2003).

More work is obviously needed to clarify these disparate findings and to unify the literature. Regardless of their differences, both studies are significant in that they isolate imitative abilities that are differentially affected in young children with autism, and they link them to other processes which might rely on separate underlying causes. The current study will address similar questions by testing six categories of behaviors commonly reported to be impaired in young children with ASD. No other study has taken such a comprehensive approach to the study of imitation in ASD, drawing upon several different theoretical perspectives and uniting them in one test. This has led to inconsistent reports of deficits of imitative ability in ASD and has created a muddy description of these deficits and how they may or may not be (1) present at an early enough age to be predictive of later development of ASD and (2) be unique to ASD.

Patterns of performance will further elucidate what types of behaviors might be most challenging for children with ASD, and whether multiple categories of behavior seem to be similarly affected. Further, the current study will be able to examine behavior sequences where aspects of the behavior to be imitated are not integral to the goal of the behavior. In other words, emotional expression, for example, can be tested directly as a separate category of behavior, but can also be tested indirectly, with expressions of emotion incorporated into other tasks. The current study will also aim to create a comprehensive test of imitation that incorporates multiple categories of disparate behaviors that can speak to which categories of behavior, if any, are most consistently impaired in individuals with ASD. The creation of a unified task of imitation should eliminate some of the methodological variations that might have contributed to incongruent findings in past work.

Rogers proposes two potential systems that could be responsible for the differences in imitation seen in individuals with autism: an affective system involved in social exchanges with important others and an apprenticeship function, cognitively mediated, that supports learning about means-end relations from others. Given her findings that children with autism imitate actions with objects better than oral-facial movements, she suggests that perhaps children learn to use the apprenticeship function of imitation, but without the benefit of the affective system to decode the affectively related information included in an exchange (Rogers et al., 2003). Thus, imitations performed by individuals with autism would appear more effortful, less exact and would lack any emotional display of pleasure at the act of imitation. This again suggests the need for imitation tasks that examine coordinated affect/other behaviors, as the current study will. By modeling certain complex behaviors with an affective display also being presented, the task used in the current study can investigate actions with objects and oral-facial movements simultaneously and shed light on whether either behavior appears harder to imitate in the presence of the other, or when presented alone.

Rogers' model becomes very attractive because it attempts to integrate earlier, empirically supported theories of autism while also considering developmental improvements. The ever-evolving nature of this model, and its responsiveness to new research, makes it the most comprehensive explanation to date. However, as with the other models, there is a biological basis to the deficits in autism that cannot yet be explained or well accounted for by any existing causal model of autism.

Mirror Neurons

Mirror Neurons are "a particular class of visuomotor neurons, originally discovered in area F5 of the monkey premotor cortex, that discharge both when the monkey does a particular action and when it observes another individual (animal or human) doing a similar action" (Rizzolatti & Craighero, 2004, p. 169). While there is no direct evidence for the presence of mirror neurons in humans, there is extensive indirect data to support their existence, coming from brain-imaging and neurophysiological studies. Such experiments show that when a person performs an action *and* when a person observes an action being performed by another without the person performing any action him/herself, his/her motor cortex becomes active (see Rizzolatti & Craighero (2004) for brief review).

In fact, there is evidence that the neurological circuitry that becomes active during imitation is the same that is activated during active observation of an action (Rizzolatti & Craighero, 2004). For example, Nishitani and Hari (2002) asked participants to observe static pictures of lip poses, to imitate them immediately after observing them, or to make such lip poses spontaneously. The activation sequence was the same during observation and immediate imitation, but differed during spontaneous posing, when the inferior parietal lobule was not activated. In addition to imitation, mirror neurons have also been linked with action understanding (Hamilton, Brindly & Frith, 2007). Fogassi et al. (2005) found that brain activity can differentiate the same movement when the goals of the action are different. In other words, differential patterns of brain activation were observed in monkeys when they grasped an object with the intention of eating the object compared to when the grasped the object to place it in a cup.

The very definition and activity of the mirror neuron system suggest that the processes it supports might be automatic rather than intentional and learned. This has been studied in relation to imitation. The concept of automatic imitation was originally put forth by Gallese and Goldman (1998). Essentially this model suggested that, in the absence of any inhibitory information at the time of observation, the neural pathways associated with copying the action would be maximally activated (Williams, 2008). One way to test whether imitation is automatic or not is to have participants observe an action but ask them to perform a similar, but slightly different action (e.g. lift a different finger from the one observed being lifted) while using functional magnetic resonance imaging (fMRI) to study brain activation (Williams, Whiten, Waiter, Pechey, & Perrett, 2007). In particular, researchers watch for evidence of motor inhibition, which would suggest that participants are intentionally not performing the action observed in order to reproduce the action they were asked to perform. No such evidence was observed in the Williams et al. study or several others using similar methodology. Therefore, imitation learning, or imitation that is learned by watching another perform a novel action, is not necessarily automatic (Williams, 2008).

Given these specific associations between the mirror neuron system and imitation and action understanding, it is not surprising that a dysfunction in the mirror neuron system has been suggested to play a critical role in deficits seen in Autism Spectrum Disorder (Williams et al., 2001). Much of the research looking at the mirror neuron system in individuals with autism has found differences in that population compared to typically developing controls. Using fMRI, Dapretto and colleagues studied brain activity in 10 children with autism and 10 typically developing children. The children were asked to imitate facial expression while in the fMRI scanner. No differences were found in imitative ability outside the scanner, but fMRI results revealed reduced activity in Broca's area in children with autism (Dapretto et al., 2006).

Others have studied motor evoked potentials (muscle activation following direct stimulation) induced using transcranial magnetic resonance stimulation (procedure using magnetic fields to stimulate muscle and brain activity) (Theoret et al., 2005). They found that observation of an action increased MEPs in control subjects but in adults with Asperger's syndrome, only observed actions directed toward the observer increase MEPs. Those actions directed away from the observer produced no MEP activity above that of the baseline (Theoret et al., 2005). The authors conclude that these findings confirm a deficit in the MNS in individuals with autism, which contributes to difficulties copying actions directed at the modeler and distinguishing self from other. Tests of mirror neuron activity during performance of ToM tasks have also been conducted. These fMRI studies suggest that, relative to controls, the mirror neuron system of individuals with autism might be underactive during ToM tasks (e.g. Baron-Cohen et al., 1999).

Williams puts forth a model that might explain many of these differences in the mirror neuron system observed in individuals with autism (2008). This model further relates the dysfunctional mirror neuron system to the Theory of Mind hypothesis. The model suggests that one crucial function of imitation is to develop representational knowledge through continuous self-other comparison. Further, he posits that the understanding of intention that accompanies intentional imitation is the foundation for the development of social cognition. Mirror neurons, in this view, are essential in the recognition of similarities and differences between observed and experienced actions.

Secondary representation seems particularly affected in autism. Secondary representations are those that consider emotional and contextual nuances of an observed behavior to understand and learn how the same behavior might differ according to these variables. For example, the act of waving good-bye might differ according to different contexts (public vs. private) or emotional ties (intimate partner vs. acquaintance) to the person who is the recipient of the wave. Indeed, the most discriminative features of autism on several diagnostic scales of ASD involve secondary representation of action, such as gesture, imitation, following attention, and pretend play (Williams, 2008). Indeed, imitation research suggests that integrating skill with action is more difficult than utilizing the skill outside an action sequence. For instance, producing/imitating gestures is more difficult for children with autism than is recognizing gestures (Smith & Bryson, 2007). Williams' model therefore posits that "the mechanisms that underpin imitation and self-other matching are fundamental to understanding autism" (Williams, 2008, p.84).

While an attractive and exciting explanation for underlying causes of autism, the role of the mirror neuron system as fully explanatory of imitation deficits seen in autism has been questioned in recent work. Work by Carpenter, Pennington & Rogers (2001) found that 2 ½ to 5 year old children with autism were not different than a control group of children with developmental delay on any of their measures of understanding intentions of others, an ability that would seem to depend upon an intact mirror neuron system (Rogers et al., 2003). A study by Hamilton, Brindley, and Frith further suggests that there is neither a general imitation deficit nor a global mirror neuron system deficit in autism (2007). These authors tested 25 children with autism and 31 typically developing children age-matched for verbal mental age on tasks of representation of action and a battery of classic tests of ToM. They found that children with autism performed like the comparison group on a goal-directed imitation task, a mirror imitation of hand actions task, a grasp imitation and motor planning task, and a gesture recognition task. These tasks were chosen based on previous work with adults that demonstrated that these tasks involve brain regions known as the mirror neuron system (Hamilton et al., 2007). However, group differences were found in performance on the Theory of Mind tasks with the children with autism performing less well than the comparison group. This study suggests that the mirror neuron system and its function or dysfunction in autism requires more study to further elucidate its role in the impairments of social cognition observed in autism.

While a good explanatory model of the role of the mirror neuron system in the deficits seen in individuals with autism does not exist, the current literature certainly points to a differential functioning of the MNS in autism. As with any other theory that attempts to explicate autism, more work is needed to support a mirror neuron deficit as fully explanatory and as specific to individuals with autism. However, the explosion of research in recent years that seeks to understand the brain function associated with many social and cognitive processes will undoubtedly help to further current knowledge of autism and its underlying neurological function and dysfunction.

The current study will be unable to test directly the role of the mirror neuron system in imitation. However, this literature is reviewed because all explanatory models of the impairments associated with ASD point to an as-yet-undiscovered underlying neurological problem as being responsible for the behavioral manifestations of the disorder. It is unlikely that abnormalities in the function of the Mirror Neuron System are fully accountable; however they provide some insight into how such a neurological dysfunction can come to affect specific behaviors in individuals with ASD.

Motor ability to reproduce adult actions

Smith and Bryson (1994) put forth a theory of imitation in autism suggesting that impairment in the perceptual organization of movements, manifested in abnormal representations of actions, accounts, in part, for the symptomology of autism. In other words, they posit that nonsocial, information-processing deficiencies in an individual’s ability to act and to comprehend the actions of others lead to the social deficits associated with autism, including that of imitation (Smith & Bryson, 1994). Dawson and Lewy (1989) agree that early experience will inhibit later normal development in children with autism. These authors believe that a basic non-social, information-processing deficit in young children with autism leads to an inability to participate in complex social interactions in these individuals. In other words, the information-processing demands of social interactions exceed the abilities of these young children and have lasting effects on their social development.

To make their case, Smith and Bryson tested imitation of non-symbolic postures and sequences (1998), as well as symbolic gestures and pantomime object use (2007), in children with ASD, children with receptive language delay (matched for age and language level with ASD group) and typically developing children (matched for language level with ASD group); comparisons were made between all types of imitative abilities. They found that the children with autism performed more poorly than comparison groups on symbolic (meaningful) and non-symbolic (meaningless) gestural imitation tasks after discounting language skills and memory deficits as potential confounds. Consistent with previous work (Rogers et al., 1996), gesture recognition was also tested and eliminated as an explanation for group differences in imitation as recognition and immediate recall of movements was unimpaired (Smith & Bryson, 1998). When imitation of symbolic actions was compared to imitation of non-symbolic actions, children with autism had more difficulty imitating the symbolic acts while children with language impairment had more difficulty imitating the non-symbolic acts. Because problems imitating symbolic actions were found relative to developmentally matched controls, Smith and Bryson suggest that this ability is impacted in autism beyond what would be expected based on difficulty with comprehension (2007). However, Rogers et al. (1996) did not find differences in the ability of adolescents with autism to imitate symbolic versus non-symbolic actions. The explanation for these different findings is unclear but could be an artifact of the age of the subjects tested, especially if imitative ability does improve with age in individuals with autism.

Smith and Bryson point to problems with praxis, the ability to carry out skilled movements at a more sophisticated level, rather than deficits with motor function, as an explanation for their findings. They point out that such an explanation is a more basic and encompassing point of view than Hobson's affective hypothesis, which focuses on deficient higher level social cognition (2007). Current theories of praxis cite two pathways by which skilled movements are carried out, depending on whether the movement is meaningful or meaningless (Buxbaum, 2001). The direct path is activated when a meaning*less* action is to be translated from a visual code to a motor action. The indirect path is activated when meaning*ful* social actions need to be recognized and produced. Smith and Bryson claim that both of these systems are impaired in individuals with autism and that some of the variability found in the literature might be attributable to individuals selecting the pathway that will maximize performance and require the least cognitive resources (Smith and Bryson, 2007).

In the view of Smith and Bryson, and other researchers who suggest that motor problems are of a dyspraxic nature in autism, motor skills are thought to be intact in individuals with autism; the deficit lies in the ability to formulate and carry out a motor plan. A contrary view might be that the motor skills themselves are not intact in individuals with autism. Vanvuchelen, Roeyers and De Weerdt (2007) explored the underlying mechanism of imitation problems in boys with autism. They tested imitation performance and correlated those scores with competence on general motor tests. They found that boys with autism, especially low-functioning boys with autism, imitated less well than controls matched for age and developmental level (IQ). In addition, children with autism, regardless of developmental level, were worse at imitating non-meaningful gestures than meaningful gestures compared to non-autistic controls. Low-functioning children with autism performed significantly worse than age matched children with intellectual disability on the motor test (Peabody Developmental Motor Scales) and high-functioning children with autism performed worse than typically developing age-matched controls on the motor test (Movement Assessment Battery for Children).

These findings support the idea that mainly perceptual-motor impairments are responsible for gestural imitation deficits seen in autism (Vanvuchelen et al., 2007). The authors offer two suggestions as to why this might be the case. First, it could be the case that adding meaning to the gestures enhanced imitation in children with autism. Or, it could be that the children likely had some previous experience with the meaningful gestures (i.e. pretend to comb your hair or salute) that made those actions easier to perform in the context of the imitation task.

Not every study that has examined motor imitation has found deficits in children with autism. Rogers et al. (2003) reported no differences among children with autism, children with developmental delay, children with Fragile X syndrome and typically developing children on tests of fine motor and gross motor (Mullen Scales of Early Learning) or praxis (newly developed task). These authors included motor functioning in a regression model to explain differences in imitation in a sample of very young (34 months) children with autism. Once verbal developmental age was accounted for, social responsiveness and fine motor age equivalent scores only explained an additional 4% of the variance. Thus, Rogers et al. conclude that motor functioning does not play an independent role in differences in imitative ability beyond that of overall developmental functioning (2003).

As is the case with the theoretical explanations of the deficits of autism, the support for the representation of action hypothesis is neither iron-clad nor fully explanatory. Motor impairments and praxis would explain differences in movement and abnormal imitative action, but would not account for the host of other social impairments of autism. However, if there is more than one mechanism responsible for the differences in imitative ability seen in individuals with autism, then this explanation cannot be ruled out completely. Again, unifying work that tests a variety of disparate behaviors thought to be impaired in ASD, based on a variety of explanatory models, is needed to integrate as many perspectives as possible so that a better, more complete understanding of imitation in ASD can emerge. The current study will attempt to do just that, while incorporating both symbolic and non-symbolic gestures to be imitated. Further, the current study includes a category of simple motor behaviors as a direct test for impairments in children with ASD. Thus, the current task will integrate the representation of action hypothesis with the affective and interpersonal development hypotheses in a single test of imitative ability in young children.

Summary. This study will attempt to unify much of the previous research about imitation in young children with ASD. Most of the past work around imitation in ASD has focused on only a few categories of behaviors. A sense of the larger picture, therefore, has been difficult to generate, as even reviews often address imitation from a theoretical perspective, thereby necessarily narrowing their presentation of the literature. The current study will incorporate each category of behavior reviewed above that has been indicated to be impaired in individuals with ASD. Hobson's approach, for example, suggests that emotional behaviors are least likely to be imitated and that self-referential behaviors will be more challenging than behaviors directed away from oneself whereas Stone et al. predict that motor movements are affected and Smith and Bryson predict that symbolic and or meaningful behaviors are more difficult to imitate than non symbolic behaviors and Rogers sees the largely cognitive components in patterns of imitated behavior as interacting with the emotional components in patterns of imitated behavior in a developmental cascade that makes imitation difficult in general. Thus, the current imitation task will encompass more types of behaviors, making it a more complete measure of imitation.

Further, this study will amend behaviors used in prior studies, making them more complex and challenging for the participants. This is done in recognition that ceiling effects are often cited when studies fail to find differences in imitation in children with ASD (e.g. Ingersoll, Schreibman, & Tran, 2003). Adding affective components to the more complex sequences of behaviors adds another layer of difficulty to the task, while also allowing for specific theories, such as the affective theory of ASD, to be tested.

Chapter 2: The study of imitation: Design and methodological issues

Imitation is not a unitary skill. Nor does it serve a unitary function. In fact, reports of impairments in imitation of one type of behavior, but not another, might be reflective of the particular function imitation is serving in that particular context (Rogers et al., 2003). Specifically, impaired imitation of facial expression might suggest a more social role for imitation while impaired imitation of (or not) actions on objects might represent an instrumental learning function. McDuffie and colleagues suggest that motor imitation, specifically, may not be a unitary construct for children with autism and, therefore, different skills might underlie the different types (2007). In their view, the context in which imitation occurs plays a crucial role in determining which abilities are tapped by a particular task. For example, the elicited imitation and free play tasks they used were presumed to require more reciprocal social interaction whereas their observational learning paradigm was presumed to require less social motivation as the reward in that task was the sensory feedback from the manipulated object, not the social interaction. This finding was important because it showed that features of the imitation task design can create performance outcomes that have little to do with the child's ability to imitate, per se.

Nor does autism present in the same way in two different individuals who carry the diagnosis (Wing, 1988). Autism is a spectrum of disorders that includes PDDNOS, Asperger syndrome and classic autism. There is variability in presentation between cases of each of the above variations of ASD, with a range of problems that may occur or may not occur in each individual case. Within classic autism, most individuals also have intellectual disability, and many are non verbal (Schultz, 2005). However, there are also individuals with autism who are verbal and who have average or above average intelligence (Volkmar et al., 2004). Further, impairments associated with autism can vary in their severity from case to case with communication problems ranging from complete lack of language to pragmatic language difficulties and with problems with social interaction manifested as lack of peer relationships altogether versus unusual pattern of contact during interactions (Boraston, Blakemore, Chilvers, & Skuse, 2007).

That being the case, it is probably unreasonable to expect any two studies of imitation, with their specific foci and varied measures, and that test two varied samples of children with autism, who may be affected in slightly or significantly different ways, to produce the same results. This leads to two points to keep in mind about deficits in imitation in autism. First, there is likely no true comparison to be made across studies, with their different samples and testing measures, or even longitudinally, as many interventions and treatments for autism employ imitation as a teaching tool. However, the fact that numerous studies have supported the notion that there is a difference in imitation skills in children with autism strongly suggests that imitation is different, if not deficient, in this population (Rogers, Hepburn, Stackhouse, & Wehner, 2003).

There are three major considerations to be addressed in the systematic study of imitation. The first of these considerations is the context in which imitation occurs. Typically, imitation is studied in either a spontaneous or an elicited scenario. The second consideration in the study of imitation is that of the form of imitation (i.e. gestural, object, facial, motor). Lastly, the specific imitation task used needs to be considered. The task will generally address both context and form in its design. All of these considerations will be addressed in this chapter.

Experimental context. There are two contextual methodologies for the study of imitative abilities in young children. In the first context, that of elicited imitation, children are specifically asked to imitate or repeat a modeled behavior. Such studies of imitation are interested in learning about children's competency and proficiency as imitators. They seek to determine what the limits of imitative ability are for children at various ages and stages of development. They do not, however, address the question of how children typically use imitation in their day to day activities (Masur, 2006). To answer questions about how imitation naturally occurs we study spontaneous imitation, an observational technique that watches for episodes of spontaneous imitation, either in the child's typical, everyday behavior or during an experimental free play session. Each methodology answers a different question about imitation in young children and each has benefits and drawbacks. Experimental studies tend to have an established system for defining an imitative act in the immediate period following the behavior being modeled, whether elicited or spontaneous. They tend to be more controlled in terms of setting and behavior of both the modeler and the imitator, making for an easier determination of an imitative act. However, the possibility remains that the experimental context itself might influence the imitative performance being measured.

Several recent studies have tested both spontaneous and elicited imitation ability in young children with autism and found that children with autism are less skilled imitators overall than other children of the same age, especially with regards to spontaneous imitation (Ingersoll, 2008a; McDuffie et al., 2007; Whiten & Brown, 1998). The Ingersoll (2008a) study was particularly well constructed in that it was the first to use the same basic imitation task in both the elicited and spontaneous contextual designs.

Seven children with autism and seven typically developing young children, group matched for non-verbal ability, participated in the same imitation task in both a structured-elicited design and a naturalistic-spontaneous condition. The presentation of task was counterbalanced by child, as was the set of toys used in each kind of task: one child might participate in the elicited task first using toy set 1 while another child might participate in the spontaneous task first using toy set 1. Results indicate that children with autism imitated less than their typically developing peers, especially during the spontaneous condition (Ingersoll, 2008a). The author suggests that a possible explanation for the specific difficulty with spontaneous imitation displayed by children with autism is the lack of explicit instruction to imitate in the spontaneous condition. Thus, the child faces the added task of understanding when to imitate, in addition to being aware that imitation is an expected behavior, in the spontaneous scenario. Such difficulties are evident in the underdeveloped spontaneous and pretend play skills of children with autism (Ingersoll, 2008a).

It has also been proposed (McDuffie et al., 2007) that imitation in a structured-elicited condition draws on different skill sets than imitation in spontaneous interactions. These authors examined fine motor ability, social reciprocity, and attention-following in three different imitative contexts in young children with ASD: direct elicited imitation, observational learning, and interactive play (2007). They were interested in the unique patterns of correlations between the types of motor imitation tasks and the associated abilities. Results indicated unique patterns of correlations for each imitation context tested. After controlling for developmental level (mental age), performance in the direct elicited task was correlated with attention-following, performance in the observational learning task was correlated with attention-following and fine motor ability, and performance in the interactive play paradigm was correlated with social reciprocity (McDuffie et al., 2007). These authors conclude that each ability uniquely contributes to motor imitation overall, with each being especially relevant in a given imitative context. For example, attention-following is a crucial skill in the ability to imitate in both the direct elicited and observational learning paradigms as the child must be able to direct their attention to the object being acted on and to the person modeling the behavior. The interactive play task was probably less demanding in terms of attention-following as the experimenter modeled an (novel) action with the toy the child was already manipulating. Citing evidence from several intervention studies targeting attention-following abilities, the authors emphasize the generalizabilty of their findings to naturalistic settings. Specifically, Whalen observed improved motor imitation after implementing an intervention focused on attention-following and initiating joint attention with 4 young children with ASD (2001).

It is hard to draw conclusions based on the McDuffie et al. study given their correlational design. However, their results speak to the need for more specific kinds of research into the various abilities imitation calls upon in different contexts. In light of this study, and those that are sure to follow, there seems a need for conservative interpretation of previous research findings regarding imitation in children with autism. Perhaps our lack of knowledge about what different imitative contexts require of the child with autism has led to over interpretation of findings in a given imitative context.

It becomes apparent that imitation likely serves different functions in different contexts while also drawing upon different social and cognitive skills in different contexts. In the current study, we are interested in whether odor will affect imitative performance of preschool age children, both with and without autism. Given that children with autism seem to be less interested in or affected by the positive mood of others, and therefore attend less to interaction partners, it is unlikely that the social reward of positive interaction that is an intrinsic feature of many imitative contexts holds much appeal for these children. The current study will use an elicited imitation paradigm to reduce the level of difficulty that may be inherent in the imitation task. I am interested in whether attention to and engagement in the imitative task might be enhanced, therefore I will employ the easiest imitation paradigm to reduce the tasks demands for the children. If improvements can be shown in the elicited imitation set-up, where the rules of the game and expectation for imitation are most obvious, then later studies should examine the influence of pleasant odor in the more ambiguous, naturalistic imitative contexts.

Categories of behavior. To fully understand the imitation deficit in autism, it is also necessary to determine which categories of behavior are (uniquely) difficult to imitate for these children. Many of the most commonly studied behaviors include emotional expressions, motor/gestural behaviors, and actions on objects. In addition, distinctions are made between symbolic actions versus non-symbolic acts and familiar versus unfamiliar acts. Much evidence for deficits of these kinds (motor/gestural, symbolic vs. non-symbolic, emotional expression) has already been presented in chapter 1.

Williams and colleagues present evidence that meaningless gestures (rather than imitations of actions with objects), unconventional actions with common objects, and sequences of actions lead to greater errors in imitation in children with autism (2001).

Further, given the unusual patterns of attention to and expression of affect associated with autism (e.g. Begeer, Rieffe, Terwogt, & Stockmann, 2006), it is not surprising that children with autism also seem to make more errors when asked to imitate facial expressions relative to other gestures or object permanence tasks (Curcio, 1978). Compared to young children with fragile X, children with other developmental disorders, and typically developing children, Rogers et al. recently found children with autism to be significantly poorer imitators of novel (unfamiliar) actions on objects and oral-facial movements, but not significantly different on manual (motor) actions (2003). There is some evidence that invisible actions that involve some body-related self-touch component (i.e. touch head, pull earlobe) might be easier for young children with autism to imitate that those invisible actions that do not involve the proprioceptive feedback (Beadle-Brown, 2004). Along similar lines, Smith tested young children on simple motor imitation in a condition where they were unable to see their own hands performing the actions (1995 as presented in Beadle-Brown, 2004). Children with autism made more errors in this condition, relative to control groups.

Imitation tasks/scales. In much of the work on imitation, and imitation in children with ASD, one of the prominently utilized imitation scales has been the Uzgiris and Hunt Sensorimotor Scales (1975). The gestural imitation scale of this instrument includes categories of items that increase in complexity: (a) imitation of a simple, familiar gesture (i.e. patting an object) (b) imitation of complex, familiar gesture (i.e. hit two blocks together); (c) imitation of unfamiliar, visible gesture (opening and closing fisted hand); (d) imitation of an unfamiliar, invisible gesture (patting head). An invisible gesture is one that the child cannot watch him/herself perform, such as pulling one's earlobe. The behaviors and objects used in the task were meant to vary so that researchers could select those that were truly novel for each child tested. This scale was administered by a researcher and items were to be repeated several times, with 2-3 gestures from each category being modeled (Uzgiris & Hunt, 1975). The scoring system developed for this instrument scored quality of imitation, with 3-5 possible scores for each gesture presented within each category, depending on the complexity of the modeled behavior. The possible scores were (1) shows interest in the examiner's performance but does not attempt to imitate gesture; (2) performs some movement in response to examiner consistently but does not imitate gesture; (3) imitates the gesture modeled through gradual approximation; (4) imitates at least one gesture immediately; and (5) imitates several gestures immediately. This scale ultimately used the best score for each item modeled as the child's imitation score.

As originally created by Uzgiris and Hunt, the age norms for passing even the most complex behaviors on the scale are 14-20 months. For this reason, researchers might alter the scale to make it more appropriate for the age groups they are testing. For example, Charman and Baron-Cohen (1994) used the Uzgiris and Hunt categories but tested behaviors used by Wetherby and Prutting (1984). These behaviors included items such as bending index finger to 90 degrees with hand stretched out in front of face (unfamiliar visible gesture) and clapping both hands onto back of own head (unfamiliar invisible gesture).

Other researchers have used Meltzoff's (1988) imitation task (Ingersoll, Schreibman, & Tran, 2003). In the Ingersoll et al. study, the procedure was modified slightly. Three pairs of novel (homemade) toys, matched for modeled action, were presented to each participant three times. The toys were presented to the child after it was modeled each time. Toys were modeled in random order with neutral affect displayed by the tester and participants were verbally encouraged to observe. The response period per modeled action was 20 seconds. During the first 10 seconds the child was given no encouragement. If they did not respond, the child was asked, “What can you do with this?” The scoring for this task was taken from Stone et al.’s Motor Imitation Scale (1997): a score of “2” was given if the child produced exact imitation; a score of “1” was given if the child produced an emerging response; and a score of “0” was given if the child did not imitate. The first action performed on the test toy was score.

There are also researchers who choose to create new imitation tasks for their testing purposes (Beadle-Brown & Whiten, 2004; Rogers et al., 2003). Stone and colleagues created the Motor Imitation Scale (MIS) to specifically study motor imitation in young children with autism (1997). The MIS is comprised of 16 single-step motor imitation items. Like the Uzgiris and Hunt (1975) instrument, the MIS is based on Piaget’s developmental sequence of imitation. Eight items require manipulation of objects and 8 require only body movements. Further, half of the items are meaningful actions (i.e. “walking” a toy dog across a table) and the other half are non-meaningful (i.e. “walking” a hairbrush across a table). Three trials of each item, made of up a minimum of three presentations per item, are included. The examiner models each item with the instructions, “Do this”. Then the child has the opportunity to imitate. Scoring is on the same three point scale described above and the best score for each item is used.

Although different research employs different scales for measuring imitation, there is some similarity between them all. All scales described here are for use in elicited imitation scenarios and give multiple opportunities for the child to demonstrate imitation. The current study will build upon the Uzgiris and Hunt scale but will incorporate different categories of behaviors to be more all-encompassing. Categories of emotional expression, simple motor behaviors, and actions on objects will be included. In addition, scoring will be per presentation and will be additive rather than selective (i.e. best or first score).

Who presents task. In most research on imitation, especially imitation in individuals with autism, the task is presented in an elicited scenario by an unfamiliar researcher (Smith, Lowe-Pearce, & Nichols, 2006). Research with one year old typically developing children reveals no difference in imitation when behaviors are modeled by familiar or unfamiliar partners (Devouche, 2004). However, it is surprising that more attention has not been given to the issue of familiarity of the interaction partner in an imitation paradigm with individuals with autism given the negative reaction to novelty often observed in this population (Smith, Pearce, & Nichols, 2006). In the current study, behaviors were modeled by the child's mother in the child's home (in most instances) as a way of making the experimental situation as familiar as possible.

Repetition of task presentation. In most studies of imitation with autism, the target behavior is modeled more than once, typically two to three times in a row (Smith, Pearce & Nichols, 2006). An example of such methodology was used by Meltzoff & Moore (1977) and again by Rogers et al. (2003). In this design, the target behavior is presented three times in quick succession in bursts of three, totaling 9 rapid presentations of each behavior. Each item was demonstrated in this way up to three times (trials) if no response was given during trials one and two. In both cases, young children were given many opportunities to imitate. Traditionally, the Uzgiris and Hunt Scale (1975) has involved repetition of items as well. In the current study, every item will be presented three times in succession, with an indication after each repetition that the child should respond (e.g, “your turn”). Further, every category of behavior will be comprised of 3 different behaviors, as per the Uzgiris and Hunt protocol for infants.

Scoring. An all-or-nothing approach was taken to scoring early studies of imitation. Using this method, a subject earns a score of 1 for each behavior correctly imitated and a score of 0 for anything but an exact imitation (i.e. DeMyer et al., 1972; Hertzig et al., 1989). However, this scoring system can give a somewhat distorted picture that children with autism are completely unable to imitate as it does not allow for approximations or attempts to be included in overall score (Smith et al., 2006). To compensate for this shortcoming, ratings of quality of imitation became the preferred scoring system. Using such scoring systems, coders rate imitative performance on a 3-4 point ordinal scale that include no response, 1-2 scores for partial imitation/approximations, and the highest score given for accurate reproduction of the modeled behavior. Then total score, average score, best score or first score might be used as the dependent variable (Smith et al., 2006). Allowing multiple repetitions to observe and imitate the same target behavior might influence imitation on later repetitions but this has not been systematically studied. In the Rogers et al. study (2003) there was no difference between first and best scores across many (up to 27) opportunities to imitate the target behavior. Further, it is important to check for reliability of coding between coders, typically reported as correlations or kappa values. Most studies that use this sort of coding system are able to report high agreement between coders (i.e. Rogers et al., 2003; Stone et al., 1997).

The current study refines the quality of imitation scoring method by incorporating the specific components of each target behavior into the scoring system. The various components that comprise the overall behavior are each scored, with the possibility for scores to be additive across each behavior and across each category of behaviors. For example, the behavior touch head is comprised of (a) looks at mom as behavior is modeled; (b) lifts arm; and (c) touches head, with one point awarded for each component demonstrated during each of the 3 repetitions of the behavior. The reason for refining the scoring system in this way was to make coding more objective and to be able to address what the child is and is not doing in relation to what was modeled. It also provides a rudimentary way of examining how imitation might improve over the course of the 3 repetitions for each behavior. This system will be explained further in the methodology.

Age. The age of children with autism tested on imitative ability has varied widely across studies. Several studies tested children across a wide range of ages (Baron-Cohen et al., 1985; Beadle-Brown & Whiten, 2004; Hertzig et al., 1989; Perra et al., 2008) while others focused on a much more narrow age range (Rogers et al., 2003; Stone et al., 1997). A few recent studies have begun to study very young children with autism (Rogers et al., 2003; Stone et al., 1997). Stone and her colleagues point out that differences in imitation between children with autism and control groups are demonstrated more consistently in younger samples than older samples (1997). In fact, both studies cited above found differences between children with autism and controls. It is improbable that researchers will be able to study children with autism younger than the 34 month olds tested by Rogers et al. (2003) as the disorder is often not diagnosed until this age or later.

In studies of imitative ability in autism, the characteristics of the control groups also compel attention. Attempts are made to match the control groups on as many variables as possible, but especially with regards to verbal ability. Chronological age is often distinguished from mental or verbal age in this process and it is common to see samples of children with a range of chronological ages that are closely matched for verbal age. This is in recognition that autism sometimes co-occurs with intellectual disability. In addition, it has been established in work with typically developing children that language skills and imitation are correlated (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979 as presented in Smith et al., 2006).

The current study included 3-5 year old typically developing children and children with autism. This age range was selected for testing as much work around imitation in ASD has focused on children in this age range and in recognition of some important developmental achievements that occur around this age, such as Theory of Mind. Because the current study is a novel test of an odor intervention, one of the first of its kind, we purposely recruited preschool age children with and without a diagnosis of autism. To allow for comparison between groups, children were matched for verbal age (receptive language) on the Peabody Picture Vocabulary Test (3^{rd} ed.) (Dunn & Dunn, 1997) and chronological age.

Chapter 3 – The current study

In addition to many of the task conditions just discussed, and as long as a child has adequate motor ability to reproduce modeled actions, sufficient social motivation to engage in an interaction and sufficient attention to a modeled behavior are necessary skills that enable an individual to follow an action and imitate it (McDuffie, Turner, Stone, Yoder, Wolery, & Ulman, 2007). These abilities will be discussed in the following section, with social motivation and attention to people/task being presented simultaneously, as that is how they are incorporated into recent work in this field. McDuffie et al. point out that these abilities may be differentially influential, depending upon the context of the task (i.e. spontaneous or elicited) (2007).

Social motivation and attention

One possibility that very few of the aforementioned studies has considered is that it is not the ability to imitate, but the social motivation and/or ability to maintain attention that is different in individuals with ASD. It could be that imitation, and our tasks to assess imitation, hold no interest or actually are distressing for children with autism. This is an important, and mostly absent, distinction that deserves attention. What if the children can perform but only in unusually supportive sensory situations?

Beadle-Brown and Whiten (2004) acknowledged that motivation might influence the results of imitation tests in their study of imitation. To account for difference in motivation to some extent, they presented two shorter sessions (rather than one long session) to younger typically developing children and to children with autism and they did not demonstrate every action to every child. Rather than explicitly citing motivation as a possible cause of differences in imitative performance, these authors modified their experimental procedure around the issue of motivation and attention to task. Essentially, less engaged children were tested differently than children and adults who were more fully engaged. This casts suspicion onto the findings of this study but also highlights the potential role of social motivation or even attention span in imitation. Not surprisingly, these authors reported no differences in imitative ability among their groups when they provided a more supportive environment for testing.

Rogers et al. (2003) also considered motivation when analyzing data from their tests of imitative ability. They compared (1) the number of non-responses and (2) number of repetitions required for children to imitate the modeled action among their groups (children with autism, children with developmental delay, children with fragile X, and typically developing children) as a measure of attention and motivation to perform the tasks. The group of children with autism did not differ from comparison groups on likelihood of responding or on number of repetitions needed to produce the act (Rogers et al., 2003). These authors further considered social motivation by including social responsiveness, as measured by 6 items on the ADOS, in a regression model to explain differences in imitation in a sample of very young (34 months) children with autism. Once verbal developmental age was accounted for, social responsiveness and fine motor age equivalent scores only explained an additional 4% of the variance. Thus, Rogers et al. conclude that social responsiveness does not play an independent role in differences in imitative ability beyond that of overall developmental functioning (2003). However these authors do not discount the possibility that early abnormalities in social engagement and responsiveness will contribute to differences in imitation observed in children with ASD.

Hobson and Hobson also examined motivation and attention in a recent study in which they compared imitative ability in 16 eleven-year-old children with autism and 16 verbally age matched eleven-year-olds with developmental delay (2007). They hypothesized that children with autism would look more at the object they were acting upon and less at the tester during an imitation task than would controls. Results indicate that children with autism spent less than half as long gazing toward the tester than did controls, though both groups looked longest at the objects (Hobson & Hobson, 2007). The authors conclude that children with autism might be less motivated to interact with the tester during such imitative episodes and so minimal sharing is necessary to produce copied actions, much less than would be required to engage with the person modeling the behaviors (Hobson & Hobson, 2007; Hobson & Lee, 1999).

One possible reason social motivation has not been more prominent in research on deficits in ASD, including that of imitation, is that social motivation is hard to define and even more difficult to measure (Fiske, 2008). In spite of the difficultly in testing social motivation, several authors point to a lack of social interest or social motivation (Berger, 2006; Grelotti et al., 2002) as a defining feature of ASD. These authors suggest that abnormal patterns of looking to human faces in infancy are indicative of abnormal social interest in young children with autism. Berger (2006) goes a step further and suggests a model of autism where the primary deficit is one of "dysfunctional affect initiation by positive social stimuli present early in life" (p. 361). In other words, Berger posits that individuals with autism do not react in the typical fashion to emotional states in others, likely from a very early age, and thus later interaction and engagement are affected. He points to early facial processing and emotional reaction abnormalities in infants with autism to support his claim (2006).

In her dissertation study, Fiske examined social motivation, operationally defined as choosing to interact with a person to achieve a goal when given the choice to interact or not. For example, one social motivation task allowed a child to choose to play with a toy on either side of a divider, where an experimenter sat with the toy on one side and just the toy sat on the other. Her other task allowed the children to choose to obtain a food item by interacting with an experimenter or via a machine. An attempt was made to control for alternative explanations in designing these tasks. For example, novelty and motivation were controlled for in the food task as both the machine and experimenter were novel and the children were motivated to obtain the food, which they had previously indicated was a favorite of theirs. There was no significant difference between children with autism and chronologically age-matched typically developing children on the toy/divider task. Neither group showed a clear preference for either side of the divider – with or without the person. Children with autism chose to obtain food from a person significantly less often than the comparison group on the second task. These results are difficult to interpret, however, given that both groups preferred the machine to the person to obtain food (Fiske, 2008).

The current study will similarly consider attention and motivation by measuring the proportion of time in the task participants spend looking at their mother (who will participate in the imitation task with them), at the toys being manipulated during the task, and away. Differences between groups will provide detail about what the children attend to during the imitation task, a potential indication of what features of the task are most motivating.

Sensory feedback as social motivation

Ingersoll, Schreibman, and Tran tested fifteen 2-4 year old children with autism age matched with fourteen 1.5 – 3 year old typically developing children on an imitation task comprised of six modeled behaviors involving three pairs of novel toys (2003). The test toys were matched for modeled action; in each pair, one toy had a sensory effect of flashing lights and sounds and the other did not. The actions modeled with each pair of toys were identical but the toys within each pair were distinguishable to eliminate carryover effects. For example, one pair of toys required opening and closing a hinged container, one circular and producing sensory feedback and one rectangular with no sensory feedback. Results did not indicate a significant difference between groups on overall imitative performance; however, there was a significant interaction of group diagnosis by type of toy. Children with autism scored significantly higher on the imitation tasks with the sensory toys than on the tasks with the non-sensory toys, a difference not found in the typically developing group. Both groups of children preferred to play with the sensory toys, as indicated by length of play during a free access session. The authors conclude that the children with autism may not be motivated to imitate by social feedback the way typically developing children are, but they may be motivated to imitated to receive a nonsocial (sensory) reward (Ingersoll, Schreibman, & Tran, 2003).

Recent efforts have begun to consider social motivation and responsiveness as a core feature of ASD and as a possible primary source of abnormalities associated with the disorder. The Ingersoll et al. study (2003) suggests that children with ASD might be more motivated by nonsocial/sensory reward features of the task rather than by the social interaction and reward intrinsic in many imitation paradigms. Given that children with autism seem to be less interested in or affected by the positive expression/mood of others, an additional path by which to influence the mood of individuals with ASD might be via environmental stimuli, such as light, sound, and odor. There is reason to believe that odor, too, might function as a sensory reward much like the lights and sounds of the toys in the Ingersoll et al. (2003) study. The next section will review some evidence that indicates that olfaction might function even better than other sensory systems as a reward situated in one's environment.

Odor is one of several intervention alternatives that can be tested with regard to the sensory environment. Others have included light or soothing background sound. There is evidence that classrooms that receive the most sunlight throughout the school day have students with increased standardized test reading and math scores at the end of a school year in said environment relative to students in the classrooms with less natural light (Pacific Gas and Electric Company, 1999). There are several reasons to believe that olfaction might be a more prominent sensory modality than any other with regard to influencing one's affective reaction to his/her environment. First, more of the human genome is devoted to olfaction than to any other sensory system (Axel & Buck, 1991). Second, the olfactory system is developed and functional from birth, if not even before (Schaal, Marlier and Soussignan, 2000). Third, the olfactory system is directly connected to the ventral tegmental area (VTA), a dopamine producing area of the brain thought to be linked to mood regulation, positive mood regulation in particular (Ashby, Isen & Turken, 1999). Other researchers have also suggested a link between the olfactory system and parts of the brain related to affective regulation (Holland, Hendriks, & Aarts, 2005), implying that odor and the olfactory system might have a direct and primary influence on emotional reactivity.

Few direct tests of the effects of odor with preschool age children have been conducted. However the ability of odor to soothe infants has been robustly demonstrated in the literature. For example, groups of infants undergoing routine (painful) blood draws were exposed to a pleasant odor to which they had been familiarized overnight, the same pleasant odor to which they had not been familiarized, or no odor. During the blood draw procedure, a scarf scented with the pleasant odor (or no odor if in the no odor condition) was held next to the infant's nose. Babies who had been familiarlized to the pleasant odor cried less during the less painful procedure (venipuncture) and were able to recover (return to baseline levels of crying and grimacing) more quickly after the more painful procedure (heelstick) (Goubet, Rattaz, Pierrat, Bullinger & Lequien, 2003).

Further, there is some indication from the infant literature that the addition of sensory modalities to an experimental situation can increase infant attention to the task and provide support to succeed at tasks sooner than they would with only unimodal stimuli (Caron, Caron & MacLean, 1988; Walker-Andrews, 1997). A recent study added a pleasant odor to an experimental set-up that already included visual and auditory inputs. Six-month-old infants were shown a woman posing a happy or sad expression while speaking dialogue that matched her expression. All infants saw both expressions, with the order counterbalanced. The babies looked longer at the happy or sad video clips overall when in the presence of odor than when not in the presence of odor (Coffield, Mayhew, Walker-Andrews, Haviland-Jones, in preparation). Therefore, a reasonable prediction for the current study seems to be that in the odor condition, children will look more at their mother (modeling the tasks) and at the toys included in the task and will look away less: attention will be enhanced when odor is present in the experimental set-up.

Pleasant odor might be situated in the same domain as positive emotion, given the olfactory system's various direct connections to affective centers in the brain (Ashby et al., 1999; Holland et al., 2005), affording pleasant odor the ability to reduce or protect from the effects of negative events (Fredrickson & Levenson, 1998). For example, one study examined behavior of a 6-year-old totally blind, hearing impaired, non-communicating boy, who, for two weeks, was exposed to a spearmint vapor during periods of contentment. Then, for a two week period, the vapor was sprayed whenever the child began to tantrum. Frequency and duration of tantrums were reduced in the presence of odor, which the author interprets as an indication that the child was calmed in the presence of the pleasant odor (Gross, 1994).

These studies indicate that odor can and does influence behavior. The mechanism through which odor influences behavior is still not completely understood, but given the direct connection to areas of the brain responsible for mood regulation and emotional experience (Ashby et al., 1999; Epple & Herz, 1999; Holland et al., 2005) it seems probable that odor has an effect on emotional experience. Our recent infant work suggests that positive odors may speed recovery from, or dampen any negative emotional effects of stress. This is evidenced by the fact that infants in this study were able to look at the sad video longer and cry less when in the odor condition than when in a no odor condition (Coffield, et al., in preparation). This position is further supported by work that examines physiological startle reactions in the presence of a pleasant or an unpleasant odor (Ehrlichman, Kuhl, Zhu, & Warrenburg, 1997). Differences in blink magnitude and heart rate indicate that the magnitude of the startle reflex was increased in the unpleasant odor condition, relative to a no odor condition. The startle reflex was significantly attenuated in the pleasant odor condition compared to the no odor condition (Ehrlichman et al., 1997). This study further suggests that pleasant odor can protect against physiological signals of stress and fear.

This study will further build upon past work through its consideration of social motivation in the context of imitation. Specifically, attention to mother and to task-related objects will be measured. Any differences related to looking would have implications for future teaching and testing of skills to children with ASD, who might not attend or focus their attention in a way that makes our instructional methods effective or our testing methods appropriate.

Further, the inclusion of pleasant odor as an intervention is expected to have implications for social motivation. Imitative differences between the odor and the no odor conditions would indicate that pleasant odor impacts the child’s ability to perform in the task by (potentially) making the experimental set-up as pleasant and as free from stress as possible or by increasing the child’s attention to information being presented. Odor as an intervention is particularly advantageous, relative to other sensory interventions, as it can be inserted into an experiment without the need to otherwise alter any feature of the task: Odor may be present or not, but the behaviors and toys used in the task can be held constant. This study will measure attention and imitative performance of each subject in the odor condition and in the no odor control condition, and will look for differences within and between groups. If odor affects performance it will aid in discriminating theories that examine the attentional or motivational deficit in ADS and will point to ways to begin to test such processes directly.

The current study

The current study will speak to some discrepancies in the literature raised by previous studies of imitative abilities in children with ASD. It will accomplish this in several ways. First, the overall imitation task will attempt to integrate multiple categories of behaviors to be tested within a single task, making the design more comprehensive than most other such studies. Rather than focusing on one category of behavior, emotional expression or motor behaviors for example, this study will incorporate both of these categories and others, bridging several areas of the literature. The six categories of behaviors included in the task are emotional expressions, simple motor behaviors, invisible gestures, visible gestures, manipulating a toy in an expected way, and imitating a toy in an unexpected way. Each category is comprised of three behaviors, and each behavior will be modeled and imitated three times in a row, consistent with past work.

In addition, sequences of behaviors were built into four of the six categories of behaviors (not emotional expressions or simple motor behaviors). Emotional expressions were often embedded as part of the behaviors in each category, as a measure of whether this makes emotional expressions more difficult to recognize and imitate. The intention was to make this task the most complete measure of imitation available, with the ability to test imitation deficits in individuals with ASD from the perspective of multiple explanatory theories at the same time.

A second novel feature of this task is the imitation behavior coding system it will utilize. This system is unique in that it scores each smaller component of the behaviors, including looking at/attending to mother, rather than using a less precise system that scores gradual approximations to the exact behavior modeled. This newly developed scoring system will provide information about what components of the whole action each child does and does not imitate for each of the three repetitions of each behavior. Therefore, information is available about what each child can accomplish, but the system relies less on subjective global judgments of how closely each behavior matched that modeled and more on what smaller pieces of the behavior are imitated.

Third, this study will attend to issues of social motivation. The experimental context will be designed to create a maximum level of comfort for the young participants: the study will be conducted in a tent designed for this study, in the child's home, with the child's mother participating in the imitation task with the child. Thus, the testing environment will be as familiar to the child as possible. To best consider social motivation, an elicited imitation task will be used. This will allow for the separated and conjoint measurements of looking/attention to task, time spent completing task, and specific behaviors imitated. Further, such a scenario will be held constant within and between participants, allowing for multiple comparisons to be made.

Finally, this study will serve as a test of pleasant odor as an intervention with preschool age children. The pleasant odor intervention is expected to create a more positive, supportive testing experience for the children, thereby increasing attention and enhancing imitative performance.

Hypotheses

Several theories were reviewed here that offer explanations for the deficits of individuals with ASD. The Theory of Mind hypothesis and the mirror neuron explanation are not directly testable in the current study, nor do they speak directly to imitative impairments. Therefore they will not be addressed in the following predictions.

As part of her interpersonal development hypothesis, Rogers suggests that the impairments in imitative ability seen in children with ASD are developmental, and that as these children get older, they acquire or refine this skill. This will be addressed in the current study through comparisons between age groups and diagnostic groups. My first hypothesis is that, overall, older children will imitate better than younger children and that typically developing children will imitate better than children with ASD of the same age.

Further, I expect these differences to be reflected in the looking behavior of the children. I predict that the older children and the typically developing children will look at mom more and will look away less during the imitation task, and that the task will take longer for the younger children and the children with ASD to complete than their older and typically developing peers.

The interpersonal development hypothesis incorporates deficits in Theory of Mind with Hobson's proposed affective impairments to create a broader theory of ASD. The focus on imitation of emotion that both Rogers and Hobson advocate will be the subject of the second hypothesis. I predict that emotional expressions will be harder for children with autism to imitate than for typically developing children to imitate. I further predict the embedded emotions will be especially difficult for all children to imitate, especially for the children with ASD. I suggest that (1) the embedded emotions themselves will be more challenging to imitate and (2) the entire behavior tasks that incorporate embedded emotions will be harder to imitate.

Williams et al. (2001) suggests that sequences of behaviors are more difficult for individuals with ASD to imitate than single actions. Several sequences of behaviors are embedded among the 18 behaviors that comprise this imitate task. I predict that sequences will be more difficult for all children to imitate, particularly the younger children and the children with ASD.

A unique exploratory aspect of this study is the use of pleasant odor as a social motivation tool. There is reason to believe that pleasant odor may serve to enhance attending and imitative performance, and may make the testing situation less stressful overall for the children. Either or some combination of these effects will ultimately increase imitative performance in the presence of odor. The mixed model design of the current study will allow for comparisons to be made within and between subjects to determine whether odor affects imitative performance and/or attention. I predict that odor will enhance imitative performance, especially for the younger children and the children with ASD. Further, I predict that odor will increase looking related to the imitations task (at mom and at toys) and will decrease looking away.

Method

Participants

The participants were recruited through preschools and daycare centers in Northern and Central New Jersey, or through parent-to-parent recommendations. Packages of information (see Appendix 1) were sent home through the schools or daycare centers explaining the study. Included with the introductory letter was a contact sheet, asking how best to reach families to schedule an appointment, and two copies of the consent forms. If families were interested in participating, they completed the contact sheet, signed the consent forms and returned the information in the self-addressed stamped envelope provided. Research appointments were scheduled at times convenient for the family (including evenings or weekends). Once research appointments had been made, participants were assigned a code number and no identifying information appeared on any further study materials.

Typically developing participants. Thirty-two children and their mothers participated in this study. There were 15 younger children (7 boys and 8 girls) with an average age of 37.6 months (SD = 3.23) and 17 older children (8 boys and 9 girls) with an average age of 53.82 months, (SD = 5.68). There were two Hispanic and 30 non-Hispanic children in the sample. Twenty-eight children were Caucasian, one was Asian and the other three were identified as other. Two children had previous training in imitation and one child received therapy/intervention (speech). Age of the mothers fell between 26 – 50 years of age. One mother had a high school diploma; the other 31 mothers had at least some college education to a graduate degree. Data from 1 additional 46 month old boy was excluded from analyses as his Peabody Picture Vocabulary Test III score was more than two standard deviations apart from those of his typically developing peers.

Participants with Autism Spectrum Disorder. Five children with Autism Spectrum Disorder and their mothers also participated in this study. All participants in this group were boys. The younger 2 boys had an average age of 41.5 months (*SD* = 7.78). The older 3 boys had an average age of 58 months (*SD* = 4.0). There were no Hispanic children in the sample. Four children were white and one was identified as other. Four children had previous training in imitation and all five boys had been receiving therapy/intervention. Age of the mothers fell between 31 – 45 years of age. All mothers had at least a college degree; one mother had a graduate degree. These families were recruited through specialized schools for children with autism located throughout New Jersey. All children with autism were diagnosed with ASD by a professional with expertise in ASD not associated with this project. One child was non-verbal. The others were verbal.

Matching Samples. Each boy with autism was matched with a typically developing boy in the same condition (odor or no odor first) of the same age with as close a matching scores on the Peabody Picture Vocabulary Test III (PPVT) as possible, as congruent with past studies (e.g. McDuffie et al., 2007; Rogers et al., 2003). An attempt was also made to match subjects on as many of the following variables as possible: ethnic group, maternal age, maternal education and number of siblings (see Table 1). In the two cases where twin boys participated, one with a diagnosis of ASD and one without, the boys were intentionally not matched with their brothers to control for environmental confounds.

Materials and measures

Cue cards for imitation task. To help ensure consistency of expression among the mothers, index cards were created to model the 18 expressions and gestures included in the imitation task. Mothers were given an opportunity to become familiar with and practice the imitation behaviors while using these index cards, before playing the imitation game with her child. Mothers also used these cue cards as prompts for which behaviors to model, and in what order, during the imitation game. During the imitation game, mothers held the cue cards in their laps, where only they could see them. If the child expressed interest in seeing the cards, the mother was instructed to finish modeling all 3 repetitions of the behavior and then show the card to her child before moving on to demonstrate the next behavior.

Researchers were photographed posing the expressions to be modeled. Those photographs were then attached to color-coded 5” x 8” index cards: a different color card was assigned to each of the 6 categories of behaviors. Three different researchers were used as models. Each researcher modeled 1 of the 3 behaviors in each of the 6 categories of behavior.

The index cards were tested for clarity. Ten undergraduate volunteers were asked to model the behaviors listed on the cards. Any difficult items were modified after each volunteer until all were represented accurately and without confusion such that they could be successfully posed using only the information presented on each card.

Test(tent) environment

Two children’s pop-up teepee tents were constructed for the purposes of this study: One tent was consistently used as the “odor” tent and the other was consistently used as the “no odor” tent. The materials used in tent construction consisted of 5 panels of durable fabric and PVC poles cut to the proper 6 foot height. Tents were large enough so that each child and his/her mother could comfortably fit inside: approximately 28 square feet of sitting area. The tents served to create a testing site that could provide a distraction-free and controlled environment. At the same time, the use of the tent as the testing site created an enclosed space that would contain the experimental odor. Both of these features were necessary to make the in-home testing feasible.

Camera

An Aiptek high definition 5 mega pixel digital video recorder (1280 x 720 HD resolution) was used to record each visit. Visits were recorded onto 1 GB Kingston SD cards. The camera was positioned on an 18 inch tall tripod approximately 3 feet from the opening of the tent. The camera was focused on the child with enough distance so as to capture the floor space around the child to ensure that manipulations involving toy props would be recorded. In the event that the child changed positions, the camera was adjusted during the visit. Temporary movements outside the scope of the camera were not followed and were, therefore, not recorded. Due to constraints of the individual testing sites, the recordings were not standardized in terms of angle, distance from the tent, or lighting conditions. The camera began recording immediately before mom modeled the first expression and continued until just after the child imitated (or was given time to imitate) the last expression or gesture.

Odor

Preparation. Johnson's® Baby Oil was the odorant used in the study. It was applied to a 3" x 3" gauze pad clipped to the inside flap of the testing tent near the child (about 1 to 2 feet away).

Intensity testing. The level of odorant was peri-threshold as there is some evidence that low levels are more potent for pre-attentive motivational effects (Degel & Koster, 1999). A peri-threshold level of odorant refers to an odorant that can be detected by an informed and trained person but is not detected or reported (even when asked) by a naïve person. To test for the peri-threshold level, three amounts (.032 mL, .0165 mL, .0160mL) of the baby oil were applied to a gauze pad using a pipette and the pads were placed in the odor tent in the laboratory. The no odor tent was set up in a separate room in the laboratory with a no odor gauze pad clipped inside the front flap. Rooms were blown-out overnight between testing of subsequent levels of the odorant. Ten people who worked or attended classes in the building were asked to rate on a Likert scale of 1-7 how strongly scented each tent was. For the .0160 mL of Johnson's® Baby Oil, the ratings were equal for the odor tent and the no odor tent, thus this level of odorant was considered at the peri-threshold level and was used in the study.

Odor preparation for testing. Each gauze pad was prepared up to one hour prior to exposure and was transported to the testing site in a plastic container designed not to absorb odor. The odorant, .0160 mL of Johnson's® Baby Oil, was applied to the center of a 3" x 3" gauze pad. Once at the testing site, the gauze pad was folded in half, center out and edges clipped, and secured to the tent flap nearest the child (about 1 to 2 feet away). The odor was placed in the tent as early as possible in the set-up process, after the PPVT had been administered, to allow for maximum exposure time. The usual time was

5 minutes. The child entered the tent, voluntarily or with encouragement from the experimenter, and played there while the study was explained to mother and then to the child.

Peabody Picture Vocabulary Test III

As a measure of receptive language ability, to be used to match children with ASD with a typically developing counterpart, the Peabody Picture Vocabulary Test III (Dunn & Dunn, 1997) was administered at the beginning of the first visit. The PPVT was conducted outside the tent environment, before the odor was introduced. Four children did not complete the PPVT. Raw scores on the PPVT ranged from 29 to 89, with the high and low scores occurring in the typically developing group ($M_{\text{older typical}} = 69.81$, $SD = 11.91$; $M_{\text{older ASD}} = 71.33$, $SD = 9.50$; $M_{\text{younger typical}} = 49.31$, $SD = 13.97$; only one younger child with ASD took the Peabody. His score was 49). The raw score was used in this study for two main reasons: (1) the 3rd revision of the PPVT is now considered out of date and so the standardized scores are no longer accurate, and (2) there was no need to use standardized scores as the age component of the standardized scores was accounted for when participants were matched for age, as well as PPVT raw score.

Test for imitation

Development of imitation task. The imitation task used in this study was modeled on Uzgiris and Hunt (1975). The gestural imitation scale of this instrument includes categories of items that increase in complexity: (a) imitation of a simple, familiar gesture (i.e. patting an object) (b) imitation of complex, familiar gesture (i.e. hit two blocks together); (c) imitation of unfamiliar, visible gesture (opening and closing fisted hand); (d) imitation of an unfamiliar, invisible gesture (patting head).This imitation task has previously been used in a number of studies that have examined imitative abilities in young children with ASD (e.g. Charman & Baron-Cohn, 1994). We modified the categories of behaviors slightly to make the task more challenging for the older typically developing participants. Our parallel categories of gestural imitation include (1) imitation of visible gesture, (2) imitation of invisible gesture, (3) imitative manipulation of an object – intended use, and (4) imitative manipulation of an object – unintended use. Additionally, we incorporated two categories of behavior that have been especially hard for children with autism spectrum disorder to imitate in more recent studies: (5) emotional expressions and (6) motor behavior (Williams et al., 2001). Examples of other difficult-to-imitate behaviors for children with autism, meaningless gestures and sequences, were incorporated into the current imitation task (see Table 2), though not as distinct categories of behavior.

Pretest for ceiling level performance of imitation behaviors. Behaviors were pre-tested with a group of 10 typically developing five year old children. Ceiling levels were not reached by all children on any task, suggesting that younger children or children with autism would find the task more challenging if imitation does improve with development or is deficient in children with autism.

Behaviors of imitation task. The various expressions/gestures included in the current task, listed by category were: (1) visible gestures (time-out sign; hands out, palms up; rub fingers, clap, rub fingers); (2) invisible gestures (pull ear lobe; open and close mouth; rub chin, rub head, rub chin); (3) manipulating toys as they were intended to be used (shake dice in Yahtzee® cup then roll; hold up talking toy and squeeze; roll toy tractor); (4) manipulating toys in a way they were not intended to be used (shake dice in

Yahtzee® cup then pretend to drink; hold talking toy as baby and rock; bang tractor on ground); (5) emotions (smile, stick-out tongue, frown); and (6) motor behaviors (touch head, reach-out arm, open and close hand). In addition, some behaviors were accompanied by emotional expressions or verbalizations. This was done to incorporate emotional expressions into longer sequences of behaviors, testing whether emotions become harder to imitate when embedded as part of a sequence of behavior.

Timing and repetition of imitation task. Each of the 18 gestures was modeled and imitated 3 times in a row, with mother demonstrating each behavior, pausing and inviting her child to imitate, and repeating this process 2 more times for every behavior. This format is consistent with prior work on imitation (Meltzoff & Moore, 1977; Rogers et al., 2003) and was incorporated to provide more information about the children's consistency of performance. For example, there may be a difference between tasks that all children can imitate successfully on all three repetitions versus tasks that all children can imitate successfully on at least one repetition versus tasks that no children can successfully imitate on any repetition. The repetition of each behavior three times allows for these differences to be found and examined.

Presentation of imitation behaviors. Order of the imitation categories varied randomly for each visit, but the emotion category was always presented first and within that category the smile was always first to provide a positive beginning. Within the categories, the behaviors were always presented in the same order for ease of coding.

Procedure

Upon arriving at the home, the researcher asked the child's mother to read and sign the consent forms and provide some demographic information about herself and her child. Next, the researcher administered the PPVT. This process lasted approximately 15 minutes. Once the PPVT was completed, the researcher spent time with the participant's mother, training her in the procedure, focusing on the behaviors she would model for her child. The mother was given the cue cards (described above) and was asked to model each behavior once while the researcher watched. If the mother performed the behavior incorrectly or was unsure what behavior the card was demonstrating, the researcher would model the behavior for the mother. Once the mother had successfully modeled each behavior one time, training was complete. Training took place during both visits to ensure that the mother was familiar with and comfortable performing the tasks. The cue cards were provided for her to use during the study so that she was reminded what to do. The child's mother was asked not to "practice" the behaviors with the child prior to the start of the task or between visit 1 and visit 2.

The researcher set up the tent before bringing mother and child into the environment. As described above, the tent was prepared in advance for the odor/no odor condition. A small video camera was set up just beyond the threshold of the tent.

Once inside the tent, the child was asked if he/she is willing to "play the game." The "game" was described as a game of copycat in which the child's mother would do something and the child would copy just what his/her mother did. The child was allowed to take anything he/she liked into the tent with him/her (favorite toy, etc.) when necessary to enhance level of comfort and cooperation during the testing process.

The participant sat on the floor in the tent facing his/her mother. The mother sat across from her child. The researcher sat about a foot outside the main opening of the tent, where both mother and child could be observed. The cue cards and toys/props were placed inside the tent, next to the child's mother, out of reach from the child. Once the researcher signaled to the mother that she could begin, she got the child's attention, "Johnny, do this," and then she looked at the first cue card, held in her lap, and performed the first behavior. As previously instructed and trained, she held each pose for a count of 3, then said "now you do it" while resting for a count of 3. This procedure was repeated 3 times for each expression, for a total of about 30 seconds. This same process was repeated for the remaining 17 expressions and gestures. All behaviors were repeated 3 times in about 30 seconds. This timing sequence was put in place based on procedures of previous imitation studies, including those of Uzgiris and Hunt (1975) and Meltzoff and Moore (1977).

The experimenter was non-reactive during the imitation task and only answered questions specifically posed to him/her. In cases of non-compliance to the task, the experimenter suggested methods to re-engage the child. For example, if a child suddenly became distracted by the toy tractor used in the previous set of behaviors, the experimenter might have suggested that mother take away the toy.

At the end of visit 2, all families were given a $20 gift card to a discount superstore in exchange for their participation. In addition, all children received an "Expert Tent Dweller" certificate with their picture on it to thank them for their participation.

Data analysis and test reliability

Pretest for coding imitation. To refine coding procedures so as to achieve maximum agreement between coders, 10 typically developing children were run through the experimental procedure once and were coded on their performance on the imitation task. The coding scheme used in this pretest was very similar to that used by Uzgiris and Hunt (1975). The children were assessed using this scoring system and were rated as: shows no interest, looks, makes a movement other than experimenter's, makes same movement by gradual approximation, makes same movement directly, or other.

Scoring of imitation task. However, reliability rates for this system were unacceptable; many codes were subjective. For example, "makes a movement other than experimenter's" and "makes same movement by gradual approximation" were confused when coding in real time. Thus, rather than marking "imitates immediately" or any of the other more subjective judgments we broke each behavior down into its subcomponents, and scored each separately. For example, the modeled behavior of "hands up with palms out while making a raspberry," was scored as: (1) looks to mom as she models behavior; (2) puts arms up; (3) with palms out; (4) makes raspberry. The child could receive a point for each component of the behavior he/she successfully imitated, with a possible total of 4 for this behavior (See Appendix 2 for entire scoring sheet). This coding system was more reliable and it provided more information about what components of any particular behavior were especially challenging for the children.

Imitation was scored once in real time as the participant and his/her mother were interacting. The researcher sat just outside the tent and coded the child's behavior. A second coder, blind to experimental condition, later scored all of the children for whom there was a video (69 out of 74). A third coder, also blind to condition, coded those behaviors where coders 1 and 2 disagreed. The score of the third coder was used in the final data analyses because disagreements were so rare, with disagreements ranging from 3% to 14% of all possible scores. Number of disagreements between coder 1 and coder 2 varied by group $t_{discrepancies}$ = 2.91, p = .007, with significantly more coding disagreements occurring among the group of younger children (M = 34, SD = 12.09) than the group of older children (M = 22.95, SD = 8.73). Number of disagreements between coders did not vary by diagnosis, (M_{autism} = 29.2, SD = 6.22; $M_{typical}$ = 27.84, SD = 12.38) or by order of presentation of odor, ($M_{odor1st}$ = 27.62, SD = 11.06; $M_{odor2nd}$ = 28.33, SD = 12.39).

Measure of looking time. In order to compare time spent looking at mom, toy/cards, or away, looking times were calculated for every participant for each visit. Looking time totals were coded from the videotapes of each visit to the nearest second. Thus, for the 5 sessions during which the video camera malfunctioned, there is incomplete or no measure of looking time. Two separate coders reached reliability rates of 90% or better for 25% of participants, with rate of agreement of 90% for looking at mom, 92% for looking at toys/cue cards, and 94% for looking away. These looking times will be used to compare within groups and between groups to test for differences between age groups and odor conditions.

Results

Three distinct sets of analyses will be conducted. First, the hypotheses that imitative performance will differ (a) between age groups and (b) between diagnostic groups will be tested. Scores from the imitation task will be analyzed according to category of behavior being tested. A distinction will be made between behaviors in each category that are simple (do not include a facial expression component) and those that contain an embedded facial expression. The categories of behavior to be tested include motor behaviors, simple emotional expressions, embedded emotional expressions, invisible tasks, embedded invisible tasks, visible tasks, embedded visible tasks, expected toy manipulations, unexpected toy manipulations, symbolic actions, and non-symbolic actions. A final test will examine all behaviors in a single analysis to test level of difficulty of each behavior relative to all other tasks. These repeated measures analyses will test for differences among the tasks of each category across time 1 and time 2 according to age (older or younger) and diagnosis (ASD or typical).

The effect of odor on imitative performance will be tested in a second set of analyses. Effect of odor will be examined using a repeated measures design, testing for effect of odor on imitation of each category of behavior according to age and odor condition.

A final set of analyses will examine the looking behavior of all the children at time 1 and time 2 according to age and diagnosis. This analyses will use the percent of total time in tent the children spent looking at mother, toys, and away. Then tests for differences in looking behavior according to odor condition will be performed.

Imitative Performance

Motor Behavior

Motor behaviors to be imitated are (1) *touch head*, (2) *reach*, & (3) *open and close hand.* In order to compare the three motor behaviors, average performance was computed for each one for visit 1 and visit 2. This equalizes the range for all variables, regardless of the number of components of which they were comprised. For example, reach was scored for (1) looks at mother and (2) reaches, with a possible total score of 6 for each visit while touches head was scored for (1) looks at mother, (2) reaches out arm, and (3) touches head, with a possible total score of 9 for each visit. Each behavioral variable was standardized by dividing by number of components, resulting in a maximum total score of 3 per visit.

The formula is

$$\text{imitation}_{\text{category}} = \Sigma \text{ component }_{1\text{-n}} \;/\; \text{n}_{\text{component}}$$

To test for differences in imitation of simple motor behaviors, a repeated measures ANOVA was conducted, with motor task and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effects for task, $F(2,66) = 7.14$, $p = .000$, $\eta^2 = .178$. Participants' imitative performance differed across motor tasks overall ($M_{\text{touchhead}} = 2.87$, $SD = .40$; $M_{\text{reach}} = 2.85$, $SD = .41$; $M_{\text{openhand}} = 2.75$, $SD = .49$) (Figure 1). No motor task was significantly different from any other. There was also a significant within subjects effect for time, $F(1,33) = 23.42$, $p = .000$, $\eta^2 = .415$. Participants performed better time 2 ($M_{\text{time2}} = 2.87$, $SD = .32$) than they did time 1 ($M_{\text{time1}} = 2.78$, $SD = .43$). There were also significant within subjects effects for Task X Age, Task X Diagnosis, Task X Age X Diagnosis (see Table 3 for statistics). Overall, the older children imitated all three motor tasks at a high level. The imitative performance of the younger children varied more across tasks. Similarly, the performance of the typically developing children varied less across tasks and was generally higher than that of the children with ASD. Performance on all three imitation tasks was lowest for young children with ASD. Older children with autism and younger typically developing children performed similarly. Older typically developing children were the highest average performers.   There were also significant within subjects effects for Time X Age and Time X Diagnosis (see Table 3 for statistics). The older children imitated at a consistently high level at both time 1 and time 2 while the younger children improved from time 1 to time 2. The typically developing children demonstrated a very slight improvement from time 1 to time 2 while the children with ASD improved by a larger margin.

There were significant within subjects effects for Motor task X Time, Task X Time X Age, and Task X Time X Diagnosis. (See Table 3 for statistics). The children's performance varied across tasks differently at time 1 and time 2, and differed across motor tasks at time 1 and time 2 differently according to their age, their diagnostic status, and the combination of both variables.

There were also significant between subjects effects for age, $F(1,33) = 7.49$, $p = .010$, $\eta^2 = .185$ and diagnosis, $F(1,33) = 5.55$, $p = .025$, $\eta^2 = .144$. In general, for motor tasks, the older children $M_{\text{older}} = 2.93$, $SD = .16$ had higher imitation scores than the younger children $M_{\text{younger}} = 2.70$, $SD = .50$ and the typically developing children $M_{\text{typical}} = 2.87$, $SD = .30$ had higher imitation scores than the children with autism $M_{\text{autism}} = 2.56$, $SD = .64$.

Simple Emotional Expressions

Simple emotion behaviors are (1) *smile*, (2) *stick out tongue*, and (3) *frown.* In order to compare the three simple emotion behaviors, performance was computed for each variable for visit 1 and visit 2. All three simple emotion behaviors involved two components, (1) looks at mother and (2) emotional expression, which were totaled, divided by number of components (two) and called *simple imitated emotion*.

To test for differences in imitation of simple imitated emotion, a repeated measures ANOVA was conducted, with emotion and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effect for simple imitated emotion, $F(1.32, 43.62) = 8.42$, $p = .003$, $\eta^2 = .203$ (Figure 2). Participants' imitative performance differed across simple emotion tasks overall ($M_{smile} = 2.82$, $SD = .46$; $M_{tongue} = 2.87$, $SD = .42$; $M_{frown} = 2.68$, $SD = .61$), with frown being significantly different (less frequently imitated) than both smile, $t(36) = 2.33$, $p = .026$ and stick out tongue, $t(36) = 2.80$, $p = .008$. Smile and stick out tongue were not different from each other.

There were also significant between subjects effects for age, $F(1, 33) = 15.64$, $p = .000$, $\eta^2 = .322$, diagnosis, $F(1, 33) = 11.13$, $p = .002$, $\eta^2 = .252$ and the interaction Age X Diagnosis, $F(1, 33) = 6.47$, $p = .016$, $\eta^2 = .164$ (Figure 3). The older children $M_{older} = 2.95$, $SD = .12$ performed better than the younger children $M_{younger} = 2.59$, $SD = .62$ and the typically developing children $M_{typical} = 2.86$, $SD = .34$ performed better than the children with autism $M_{autism} = 2.37$, $SD = .86$. Overall, the older typically developing children imitated simple emotion best ($M = 2.95$, $SD = .11$) followed by the older children with ASD ($M = 2.67$, $SD = .58$), the younger typically developing children ($M = 2.50$, $SD = .78$), and the younger children with ASD ($M = 0.92$, $SD = 1.30$).

Embedded Emotion

There are seven additional emotional expressions, embedded among the 18 imitation tasks that were not included in the pre-determined simple emotional expression category. These behaviors are (1) *smile during rub chin sequence,* (2) *smile during rub finger sequence,* (3) *Oface (surprise face) with timeout,* (4) *gasp while pulling earlobe,* (5) *haha while squeaking doll,* (6) *raspberry (disgust) with hands up,* and (7) *growl (anger) while banging truck.*

This analysis will examine imitation of emotional expression apart from the task during which it was performed to test whether imitation of emotional expressions is more difficult when the expression is embedded within a larger behavioral sequence than when the expression occurs alone. This means that only the emotional expression was computed for time 1 and time 2, and no other behavioral components of the task were included. Subsequent analyses, such as analyses of invisible actions and symbolic actions, will include emotional (or facial) expression as a component of the tasks where they were performed.

To test for differences in imitation of embedded imitated emotion, a repeated measures ANOVA was conducted, with emotion and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effect for time, $F(1,33) = 5.88$, $p = .021$, $\eta^2 = .151$. Overall, participants imitated embedded emotions better time 2 ($M_{\text{time2}} = 2.13$, $SD = .70$) than they did time 1 ($M_{\text{time1}} = 1.89$, $SD = .77$) (Figure 4).

There were also significant between subjects effects for age, $F(1,33) = 17.41$, $p = .000$, $\eta^2 = .345$ and for diagnosis, $F(1,33) = 4.53$, $p = .041$, $\eta^2 = .121$. The older children (M_{older} = 2.39, SD = .34) performed better than the younger children ($M_{younger}$ = 1.57, SD = .78) and the typically developing children ($M_{typical}$ = 2.07, SD = .65) performed better than the children with autism (M_{autism} = 1.63, SD = 1.00).

Embedded Emotion vs. Simple Emotion

The means for imitation of embedded emotion and simple emotion suggest that embedded emotion is more difficult for the children to imitate. To compare these types of emotions across the same expression, the score for smile in the simple emotion category will be compared to the embedded smiles in the embedded emotion category. A repeated measures ANOVA was conducted with type of smile as the within subjects variable and age and diagnosis as the between subjects variables. There was a significant within subjects effect for type of smile, $F(1,33) = 19.32$, $p = .000$, $\eta^2 = .369$ (Figure 5). Overall, imitation scores were better for simple smile (M = 2.70, SD = .73) than they were for embedded smile (M = 1.72, SD = .92). There were also significant between subjects effects for age, $F(1,33) = 14.13$, $p = .001$, $\eta^2 = .300$, and diagnosis, $F(1,33) = 5.31$, $p = .028$, $\eta^2 = .139$. The older children (M_{older} = 2.57, SD = .38) performed better than the younger children ($M_{younger}$ = 1.79, SD = .82) and the typically developing children ($M_{typical}$ = 2.29, SD = .66) performed better than the children with autism (M_{autism} = 1.75, SD = 1.03).

Simple Motor vs. Simple Emotion

The average performance on the motor behaviors across both visits was compared with the average performance on the simple emotion behaviors across both visits to determine whether a simple emotion was more difficult to imitate than a simple motor behavior with no embedded facial expression or sequence of action to imitate. A repeated measures ANOVA was conducted with type of task (motor vs. simple emotion) as the within subjects variable and age and diagnosis as the between subjects variables. There were significant within subjects effects for task, $F(1,33) = 6.17$, $p = .018$, $\eta^2 = .157$, Task X Age, $F(1,33) = 7.29$, $p = .011$, $\eta^2 = .181$, and Task X Diagnosis, $F(1,33) = 4.84$, $p = .035$, $\eta^2 = .128$ (Figure 6). Overall, subjects imitated motor tasks ($M = 2.83$, $SD = .37$) better than simple emotions ($M = 2.79$, $SD = .46$) and difference in performance on the two kinds of tasks varied according to age and diagnosis. There were also significant between subjects effects for age, $F(1,33) = 12.45$, $p = .001$, $\eta^2 = .274$, diagnosis, $F(1,33) = 9.00$, $p = .005$, $\eta^2 = .214$ and the interaction Age X Diagnosis, $F(1,33) = 5.07$, $p = .031$, $\eta^2 = .133$. The older children $M_{\text{older}} = 2.94$, $SD = .10$ performed better than the younger children $M_{\text{younger}} = 2.65$, $SD = .55$ and the typically developing children $M_{\text{typical}} = 2.86$, $SD = .31$ performed better than the children with autism $M_{\text{autism}} = 2.46$, $SD = .74$. Overall, the older typically developing children imitated the simple tasks best ($M = 2.96$, $SD = .08$) followed by the older children with ASD ($M = 2.84$, $SD = .15$), the younger typically developing children ($M = 2.75$, $SD = .42$), and the younger children with ASD ($M = 1.90$, $SD = 1.03$).

Invisible Behaviors

The three pre-determined invisible behaviors are (1) *pull earlobe and gasp*, (2) *open and close mouth*, and (3) *rub chin sequence while smiling*. Average performance was computed for each variable for visit 1 and visit 2. This equalizes the range for all variables, regardless of the number of components of which they were comprised. For example, open and close mouth was scored for (1) looks at mother and (2) opens and close mouth, with a possible total score of 6 for each visit while pull earlobe and gasp was scored for (1) looks at mother, (2) extends arm up, (3) pulls earlobe and (4) gasps, with a possible total score of 12 for each visit. Each behavior variable was standardized by dividing by number of components, resulting in a maximum total score of 3 per visit.

To test for differences in imitation of invisible behaviors, a repeated measures ANOVA was conducted, with invisible behavior task and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effect for task, $F(1.69,55.86) = 15.24$, $p = .000$, $\eta^2 = .316$. Participants' imitative performance differed across the invisible tasks overall, $M_{earlobe} = 2.45$, $SD = .57$, $M_{openmouth} = 2.79$, $SD = .46$, $M_{chin} = 2.29$, $SD = .67$ with open mouth being significantly different than both pull earlobe, $t(36) = 4.74$, $p = .000$ and rub chin, $t(36) = 5.88$, $p = .000$. Pull earlobe and rub chin were not different from each other.

There was a significant interaction for Task X Age, $F(1.69,55.86) = 4.97$, $p = .014$, $\eta^2 = .131$ (Figure 7). Task performance varied according to age, with older children performing all three tasks better than younger children, especially the rub chin sequence. This is further supported by the finding of a significant between subjects effect for age, $F(1,33) = 14.57$, $p = .001$, $\eta^2 = .306$. The older children $M_{older} = 2.73$, $SD = .21$ performed better on the invisible tasks than did the younger children $M_{younger} = 2.25$, $SD = .60$. There were no diagnosis differences.

Embedded Invisible Behaviors

There are two additional behaviors, from among the 18 that comprise the imitation task, that are invisible but were not included in the pre-determined invisible behavior category. These behaviors are (1) *touch head* and (2) *pretend to drink the dice in the cup.* Two of the five invisible behaviors are simple, with no embedded facial

expression or sequence pattern to imitate. These are (1) *touch head* and (2) *open and close mouth.* Three of the invisible behaviors involve embedded facial expression (not necessarily emotional expression) as a component. These are (1) *pull earlobe and gasp,* (2) *rub chin sequence while smiling*, and (3) *pretend to drink dice with oooface.*
To test for differences among the embedded invisible tasks, a repeated measures ANOVA was conducted with embedded invisible tasks (earlobe, rub chin, drink dice) and time as the within subjects variables and age and diagnosis as the between subjects variables. These analyses were conducted for only the action components of the above behaviors and did not include the facial expression.

There were no significant within subjects effects for imitation of invisible tasks with embedded facial expressions. There were significant between subjects effects for age, diagnosis, and Age X Diagnosis, ($F_{age}(1,33) = 31.96$, $p = .000$, $\eta^2 = .492$; $F_{diagnosis}(1,33) = 10.94$, $p = .002$, $\eta^2 = .249$, $F_{interaction}(1,33) = 11.53$, $p = .002$, $\eta^2 = .259$). Older children imitated better overall ($M_{older} = 2.77$, $SD = .17$, $M_{younger} = 2.26$, $SD = .58$) and typically developing children ($M_{typical} = 2.59$, $SD = .39$) imitated better than children with ASD ($M_{autism} = 2.18$, $SD = .86$). Overall, the older typically developing children and older children with ASD imitated embedded invisible actions best ($M = 2.76$, $SD = .18$; $M = 2.78$, $SD = .15$, respectively), followed by the younger typically developing children ($M = 2.39$, $SD = .46$), and the younger children with ASD ($M = 1.28$, $SD = .49$).

The embedded invisible task variables were computed with and without the embedded facial expressions, and analyses were conducted using both sets of variables. Results were similar for both analyses. The inclusion (or exclusion) of the facial expressions in overall performance score for these behaviors did not alter the differences within or between groups – the same effects were significant either way. Therefore, the variables that include facial expressions were used in the grand comparative analysis (at end of imitation section).

Visible Behaviors

The three pre-determined visible behaviors are (1) *timeout sign while making Oface*, (2) *hands up while making raspberry*, and (3) *rub fingers sequence while smiling*. Average performance was computed for each variable for visit 1 and visit 2. This equalizes the range for all variables, regardless of the number of components of which they were comprised. For example, timeout with Oface was scored for (1) looks at mother, (2) puts arms out, (3) makes T, and (4) makes Oface, with a possible total score of 12 for each visit while the rub finger sequence was scored for (1) looks at mother, (2) rubs fingers, (3) claps (4) rubs fingers again, and (5) smiles, with a possible total score of 15 for each visit. Each behavior variable was standardized by dividing by number of components, resulting in a maximum total score of 3 per visit.

To test for differences in imitation of visible behaviors, a repeated measures ANOVA was conducted, with visible task and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effect for task, $F(2,66) = 5.46$, $p = .006$, $\eta^2 = .142$ (Figure 8). Participants' imitative performance differed across the visible tasks overall, $M_{\text{timeout}} = 2.56$, SD = .61, $M_{rasp} = 2.51$, $SD = .70$, $M_{\text{rubfingers}} = 2.19$, $SD = .76$ with the rub finger sequence being significantly different than both timeout, $t(36) = 4.14$, $p = .000$ and raspberry, $t(36) = 3.33$, $p = .002$. Timeout and raspberry were not different from each other. There was also a significant within subjects effect for time, $F(1,33) = 6.88$, $p = .013$, $\eta^2 = .172$.

Participants performed better time 2 (M_{time2} = 2.50, *SD* = .57) than they did time 1 (M_{time1} = 2.34, *SD* = .72).

There was a significant between subject effect for age, $F(1,33) = 11.52$, $p = .002$, $\eta^2 = .259$. The older children M_{older} = 2.67, *SD* = .40 performed better on the visible tasks than did the younger children $M_{younger}$ = 2.13, *SD* = .70. There was another significant between subjects effect for diagnosis, $F(1,33) = 11.66$, $p = .002$, $\eta^2 = .261$. The typically developing children $M_{typical}$ = 2.52, *SD* = .51 performed better than children with autism M_{autism} = 1.79, *SD* = .94.

Embedded Visible Behaviors

There are six additional behaviors, from among the 18 that comprise the imitation task, that are visible but that were not included in the pre-determined visible behavior category. These behaviors are (1) *reach,* (2) *open and close hand,* (3) *roll dice with oooface,* (4) *hold out toy, squeak, and say haha,* (5) *rock toy and coo,* and (6) *bang truck and growl*. Two of the nine visible behaviors are simple, with no embedded facial expression or sequence pattern to imitate. These are (1) *reach* and (2) *open and close hand.* Seven of the visible behaviors involve embedded facial expression as a component. These are (1) *timeout while making Oface,* (2) *raspberry with hands up,* (3) *rub finger sequence while smiling*, (4) *roll dice while making oooface,* (5) *hold out toy, squeak, and say haha,* (6) *rock toy and coo,* and (7) *bang truck and growl.* To test for differences among the embedded visible tasks, a repeated measures ANOVA was conducted with embedded visible tasks (time out, raspberry, rub fingers, roll dice, roll truck, squeak toy, rock toy, bang truck) and time as the within subjects variables and age and diagnosis as the between subjects variables. These analyses were conducted for only the action components of the above behaviors and did not include the facial expression.

There were significant within subjects effects for embedded visible task, $F(6,198) = 4.75$, $p = .000$, $\eta^2 = .126$, and Task X Time, $F(4.35,143.45) = 2.56$, $p = .037$, $\eta^2 = .072$ (Figure 9). Overall, performance on the visible tasks was different time 1 than at time 2 within subjects. There were significant between subjects effects for age, diagnosis, and Age X Diagnosis, ($F_{age}(1,33) = 19.99$, $p = .000$, $\eta^2 = .377$; $F_{diagnosis}(1,33) = 16.14$, $p = .000$, $\eta^2 = .329$, $F_{interaction}(1,33) = 6.68$, $p = .014$, $\eta^2 = .168$). Older children imitated better overall ($M_{older} = 2.74$, $SD = .28$, $M_{younger} = 2.33$, $SD = .54$) and typically developing children ($M_{typical} = 2.62$, $SD = .34$) imitated better than children with ASD ($M_{autism} = 2.06$, $SD = .82$). Overall, the older typically developing children imitated embedded visible actions best ($M = 2.77$, $SD = .27$), followed by the older children with ASD ($M = 2.53$, $SD = .32$), the younger typically developing children ($M = 2.46$, $SD = .34$), and the younger children with ASD ($M = 1.35$, $SD = .90$).

The embedded visible task variables were computed with and without the embedded facial expressions, and analyses were conducted using both sets of variables. Results were similar for both analyses. The inclusion of the facial expressions in overall performance score for these behaviors only affected one within subjects effect. The task X time interaction above becomes a main effect for time when facial expressions are included. All other effects remain significant either way. The variables that include facial expressions were used in the grand comparative analysis (at end of imitation section).

Expected toy manipulations

The three pre-determined expected toy manipulations are (1) *roll dice while making ooofface*, (2) *hold up toy, squeak, and say haha,* and (3) *roll truck and say vroom*. Average performance was computed for each variable for visit 1 and visit 2. This equalizes the range for all variables, regardless of the number of components of which they were comprised. For example, hold up toy and squeak was scored for (1) looks at mother, (2) holds doll up, (3) squeaks, and (4) says haha, with a possible total score of 12 for each visit while the roll dice action was scored for (1) looks at mother, (2) puts dice in cup, (3) shakes cup (4) rolls dice, and (5) makes ooo face, with a possible total score of 15 for each visit. Each behavior variable was standardized by dividing by number of components, resulting in a maximum total score of 3 per visit.

To test for differences in imitation of expected toy manipulations, a repeated measures ANOVA was conducted, with expected manipulation and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effect for manipulation, $F(1.5,49.44) = 22.40$, $p = .000$, $\eta^2 = .404$. Participants' imitative performance differed across the visible tasks overall, $M_{\text{dice}} = 2.40$, $SD = .43$, $M_{truck} = 2.77$, $SD = .34$, $M_{\text{squeaktoy}} = 2.26$, $SD = .68$ with roll truck being significantly different than both roll dice, $t = 6.14$, $p = .000$ and squeak toy, $t(36) = 6.67$, $p = .000$. Roll dice and squeak toy were not different from each other. There were also significant interactions for Task X Age, $F(1.5,49.44) = 6.17$, $p = .008$, $\eta^2 = .157$, and Task X Age X Diagnosis, $F(1.5,49.44) = 3.73$, $p = .043$, $\eta^2 = .102$ (Figure 10). There was also a significant between subjects effect for age, $F(1,33) = 20.12$, $p = .000$, $\eta^2 = .379$, diagnosis, $F(1,33) = 10.69$, $p = .003$, $\eta^2 = .245$, and Age X Diagnosis, $F(1,33) = 8.77$, $p = .006$, $\eta^2 = .210$. Older children performed better overall ($M_{\text{older}} = 2.64$,

SD = .33, M_{younger} = 2.28, SD = .46) the typically developing children M_{typical} = 2.53, SD = .34 performed better than children with autism M_{autism} = 2.12, SD = .73. Overall, the older typically developing children imitated expected toy manipulations best (M = 2.65, SD = .36), followed by the older children with ASD (M = 2.60, SD = .08), the younger typically developing children (M = 2.40, SD = .29), and the younger children with ASD (M = 1.40, SD = .62).

Unexpected toy manipulations

The three pre-determined unexpected toy manipulations are (1) *pretend to drink dice while making oooface*, (2) *rock toy and coo,* and (3) *bang truck and growl*. Average performance was computed for each variable for visit 1 and visit 2. This equalizes the range for all variables, regardless of the number of components of which they were comprised. For example, rock toy and coo was scored for (1) looks at mother, (2) holds doll, (3) rocks, and (4) coos, with a possible total score of 12 for each visit while pretend to drink dice was scored for (1) looks at mother, (2) puts dice in cup, (3) shakes cup (4) pretends to drink, and (5) makes ooo face, with a possible total score of 15 for each visit. Each behavior variable was standardized by dividing by number of components, resulting in a maximum total score of 3 per visit.

A repeated measures ANOVA was conducted, with unexpected manipulation and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effect for manipulation, $F(1.5,49.5) = 4.62$, $p = .023$, $\eta^2 = .123$ (Figure 11). Participants' imitative performance differed across the unexpected manipulation overall, M_{dice} = 2.25, SD = .47, M_{truck} = 2.58, SD = .51, M_{toy} = 2.27, SD = .75 with bang truck being significantly different than both drink dice, $t(36) = 5.61$, $p = .000$ and rock toy, $t(36) = 3.36$, $p = .002$. Drink dice and rock toy did not differ from each other. There were also significant between subjects effects for age, $F(1,33) = 20.49$, $p = .000$, $\eta^2 = .383$, diagnosis, $F(1,33) = 4.42$, $p = .043$, $\eta^2 = .118$, and Age X Diagnosis, $F(1,33) = 5.79$, $p = .022$, $\eta^2 = .149$. Older children performed better overall ($M_{older} = 2.61$, $SD = .31$, $M_{younger} = 2.09$, $SD = .54$) the typically developing children $M_{typical} = 2.41$, $SD = .44$ performed better than children with autism $M_{autism} = 2.12$, $SD = .83$. Overall, the older children with ASD imitated unexpected toy manipulations best ($M = 2.66$, $SD = .24$), followed by the older typically developing children ($M = 2.60$, $SD = .32$), the younger typically developing children ($M = 2.19$, $SD = .45$), and the younger children with ASD ($M = 1.32$, $SD = .71$).

Symbolic Actions

There are eight behaviors, among the 18 that comprise the imitation task, that are symbolic or meaningful in nature. These include (1) *smile,* (2) *stick out tongue,* (3) *frown,* (4) *rock toy and coo,* (5) *timeout with Oface,* (6) *raspberry with hands up,* (7) *pretend to drink dice,* and (8) *roll truck and say vroom.* Average performance was computed for each variable for visit 1 and visit 2. This equalizes the range for all variables, regardless of the number of components of which they were comprised. Each behavior variable was standardized by dividing by number of components, resulting in a maximum total score of 3 per visit.

A repeated measures ANOVA was conducted, with symbolic task and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effect for symbolic task, $F(4.36,143.73) = 8.05$, $p = .000$, $\eta^2 = .196$. Participants' imitative performance differed across the symbolic tasks

(Figure 12 and Table 4). There were also significant between subject effects for age, $F(1,33) = 19.41$, $p = .000$, $\eta^2 = .370$, diagnosis, $F(1,33) = 11.80$, $p = .002$, $\eta^2 = .263$, and Age X Diagnosis, $F(1,33) = 6.96$, $p = .013$, $\eta^2 = .174$. Older children performed better overall ($M_{older} = 2.77$, $SD = .21$, $M_{younger} = 2.38$, $SD = .54$) and the typically developing children $M_{typical} = 2.65$, $SD = .33$ performed better than children with autism $M_{autism} = 2.19$, $SD = .82$. Overall, the older typically developing children imitated symbolic actions best ($M = 2.79$, $SD = .20$), followed by the older children with ASD ($M = 2.66$, $SD = .25$), the younger typically developing children ($M = 2.50$, $SD = .37$), and the younger children with ASD ($M = 1.50$, $SD = .98$).

Non-symbolic Actions

There are nine behaviors, among the 18 that comprise the imitation task, that are non-symbolic or meaningless in nature. These include (1) *touch head,* (2) *reach,* (3) *open and close hand,* (4) *open and close mouth,* (5) *rub chin sequence while smiling,* (6) *rub fingers sequence while smiling,* (7) *roll dice,* and (8) *bang truck and growl,* and (9) *pull earlobe and gasp.* Average performance was computed for each variable for visit 1 and visit 2. This equalizes the range for all variables, regardless of the number of components of which they were comprised. Each behavior variable was standardized by dividing by number of components, resulting in a maximum total score of 3 per visit.

A repeated measures ANOVA was conducted, with non-symbolic task and time as the within subjects variables and age and diagnosis as the between subjects variables. There was a significant within subjects effect for non-symbolic task, $F(5.55,183.01) = 15.81$, $p = .000$, $\eta^2 = .324$, Task X Age, $F(5.55,183.01) = 3.89$, $p = .002$, $\eta^2 = .106$, and Task X Diagnosis, $F(5.55,183.01) = 3.05$, $p = .090$, $\eta^2 = .085$.

Participants' imitative performance differed across the non-symbolic tasks and varied by age and diagnosis (Figure 13 and Table 5). There were also significant between subject effects for age, $F(1,33) = 17.78$, $p = .000$, $\eta^2 = .350$, diagnosis, $F(1,33) = 7.29$, $p = .011$, $\eta^2 = .181$, and Age X Diagnosis, $F(1,33) = 4.15$, $p = .050$, $\eta^2 = .112$. Older children performed better overall ($M_{older} = 2.77$, $SD = .15$, $M_{younger} = 2.35$, $SD = .51$) and the typically developing children $M_{typical} = 2.62$, $SD = .35$ performed better than children with autism $M_{autism} = 2.28$, $SD = .69$. Overall, the older typically developing children imitated symbolic actions best ($M = 2.79$, $SD = .15$), followed by the older children with ASD ($M = 2.66$, $SD = .16$), the younger typically developing children ($M = 2.44$, $SD = .42$), and the younger children with ASD ($M = 1.68$, $SD = .82$).

Symbolic Actions vs. Non-symbolic Actions

To test whether the symbolic nature of the task affected performance, a repeated measures ANOVA was conducted with type of task (symbolic vs. non-symbolic) and time was within subjects variables and age and diagnosis as between subjects variables. There was a significant within subjects effect for time, $F(1,33) = 6.69$, $p = .014$, $\eta^2 = .169$. Imitation of both types of tasks was better time 2 ($M_{time2} = 2.63$, $SD = .40$) than time 1 ($M_{time1} = 2.54$, $SD = .46$). There were also significant between subject effects for age, $F(1,33) = 19.54$, $p = .000$, $\eta^2 = .372$, diagnosis, $F(1,33) = 9.92$, $p = .003$, $\eta^2 = .231$, and Age X Diagnosis, $F(1,33) = 5.76$, $p = .022$, $\eta^2 = .149$. Older children performed better overall ($M_{older} = 2.77$, $SD = .17$, $M_{younger} = 2.37$, $SD = .52$) and the typically developing children $M_{typical} = 2.64$, $SD = .33$ performed better than children with autism $M_{autism} = 2.24$, $SD = .76$. Overall, the older typically developing children imitated symbolic actions best ($M = 2.79$, $SD = .16$), followed by the older children with ASD

($M = 2.67$, $SD = .20$), the younger typically developing children ($M = 2.47$, $SD = .39$), and the younger children with ASD ($M = 1.59$, $SD = .90$).

All imitation categories – Grand analysis for imitation

To test whether imitative performance varied by type of task, the following categories of behaviors were included in a single analysis: (1) *motor,* (2) *simple emotion,* (3) *embedded emotion,* (4) *simple invisible,* (5) *embedded invisible,* (6) *simple visible,* (7) *embedded visible.* Because the symbolic and non-symbolic variables contain tasks already represented in the other behavior categories, this analysis did not include the symbolic and non-symbolic categories.

A repeated measures ANOVA was conducted with type of task and time as within subjects variables and age and diagnosis as between subjects variables. There were significant within subjects effects for task, $F(3.58,118.21) = 37.49$, $p = .000$, $\eta^2 = .532$, Task X Age, $F(3.58,118.21) = 7.99$, $p = .000$, $\eta^2 = .195$, Task X Diagnosis, $F(3.58,118.21) = 4.95$, $p = .002$, $\eta^2 = .30$, time, $F(1,33) = 5.62$, $p = .024$, $\eta^2 = .145$, Task X Time, $F(3.92,129.38) = 4.99$, $p = .001$, $\eta^2 = .131$, and Task X Time X Diagnosis, $F(3.92,129.38) = 4.79$, $p = .001$, $\eta^2 = .127$ (see Figure 14). There were also significant between subjects effects for age, $F = 17.81$, $p = .000$, $\eta^2 = .350$, diagnosis, $F = 8.23$, $p = .007$, $\eta^2 = .200$, and Age X Diagnosis, $F = 4.87$, $p = .034$, $\eta^2 = .128$.

Follow-up paired samples t-tests indicate that imitation of simple emotion is significantly different than imitation of simple invisible tasks, motor tasks, and simple visible tasks, which are not significantly different from each other. Embedded visible, embedded invisible and embedded emotion tasks all are significantly different from each other and from all other tasks (Table 6).

Peabody Score

To determine how Peabody scores were distributed across the sample, raw scores for the 33 children who completed the Peabody Picture Vocabulary Test III were analyzed using a univariate ANOVA with age and diagnosis as the independent variables. There was a significant effect for age, $F(3,29) = 7.78$, $p = .009$, $\eta^2 = .350$, with the older children scoring higher than the younger children ($M_{older} = 70.05$, $SD = 11.34$, $M_{younger} = 49.29$, $SD = 13.42$). There was no significant effect for diagnosis. Average PPVT III score for the entire sample was 61.24, (SD = 15.94).

Matched pairs imitation performance – a descriptive analysis

To determine how the children with ASD imitated relative to a typically developing child matched as closely as possible for age, Peabody score and odor condition, imitative performance for four categories of behavior was examined. Imitative performance of (1) simple invisible behaviors (the easiest to imitate) was compared with (2) simple emotion (middle of scale in terms of difficulty to imitate), (3) embedded invisible behaviors (hard to imitate) and (4) simple embedded emotion (hardest to imitate) for each pair of children. These behaviors were chosen to represent the range of difficulty levels the different imitative tasks present, as indicated by the grand analysis conducted above. Simple invisible behaviors were the easiest to imitate overall and embedded emotion was the hardest to imitate overall. The embedded invisible and simple emotion categories were also included to (1) determine if similar patterns of scores held up for these individual children as for the entire sample and (2) to specifically determine if the more complex version of these categories was consistently more difficult to imitate for each child. Performance for each pair is described below.

The first pair is made up of 2 males who both refused to complete the Peabody. Subject 11 is a 36 month old boy with a diagnosis of ASD, and subject 19 is a 41 month old typically developing boy (Figure 15). The young boy with ASD (11) imitated less well in all four categories than the typically developing boy, and did not imitate either emotional expression at all. The typically developing child (19) imitated each behavior as would have been predicted, with highest performance in the easiest to imitate category (simple invisible actions imitation score = 2.92) and progressively lower performance in each harder to imitate category, with lowest imitation in the hardest to imitate category (embedded emotion imitation score = 0.79).

The second pair is made up of 2 males: Subject 34 is a 47 month old boy with a diagnosis of ASD and Peabody score of 49, and subject 23 is a 48 month old typically developing boy with a Peabody score of 51 (Figure 16). The young boy with ASD (34) imitated less well in the three harder to imitate categories than the typically developing boy, but imitated better than his age-matched peer on simple invisible behaviors (score 3.00 vs. 1.83). His performance declined as would have been expected across the three more difficult to imitate behaviors, with his lowest imitation score (1.43) occurring in the embedded emotion category. The typically developing child (23) imitated simple invisible behaviors less well than would have been predicted (score = 1.83), scoring lower in this category than his peer with ASD. In the three harder to imitate categories, his scores were higher than his peer with ASD for each behavior, and scores declined as would have been predicted, with highest performance in the easier to imitate category (simple emotion imitation score = 3.00) and progressively lower performance in each harder to imitate category, with lowest imitation score in the hardest to imitate category (embedded emotion = 2.00).

The third pair is made up of 2 males: Subject 17 is a 54 month old boy with a diagnosis of ASD, and a Peabody score of 62 while subject 36 is a 53 month old typically developing boy with a Peabody score of 54 (Figure 17). The boy with ASD (17) scored higher than his age-matched typically developing peer on imitation of all categories except simple invisible behaviors. Both boys earned maximum scores (3.00) on imitation of simple invisible behaviors. The boy with ASD did not decline on imitation of simple emotion (score = 3.00), as would have been expected, but subject 36 did imitate simple emotion less well (score = 2.67). Both boys demonstrated the expected decline in imitation for embedded invisible actions and embedded emotions, with the child with ASD imitating both categories of behavior better (scores of 2.55 and 2.36) than the typically developing boy (scores of 2.18 and 1.57).

The fourth pair is made up of 2 males: Subject 27 is a 58 month old boy with a diagnosis of ASD and a Peabody score of 71, and subject 2 is a 60 month old typically developing boy who refused to complete the Peabody (Figure 18). The boys imitated simple invisible behaviors and simple emotions equally well, both earning maximum scores (3). They were also nearly equivalent in imitation of embedded invisible behaviors, earning scores of 2.72 (subject 2) and 2.73 (subject 27). The boy with ASD (27) imitated embedded emotions slightly better than his age-matched peer. Again, both boys scored high with scores of 2.5 and 2.29 respectively.

The final pair is made up of 2 males: Subject 29 is a 62 month old boy with a diagnosis of ASD and a Peabody score of 81, and subject 28 is a 58 month old typically developing boy with a Peabody score of 73 (Figure 19). The boy with ASD (29) imitated less well across all four categories of behavior than the typically developing boy, and earned particularly low imitation scores in the simple (2.00) and embedded emotion categories (1.86). His score for imitation of simple emotion was slightly higher than his score for embedded emotion, with both being noticeably lower than his other two scores and than all scores of his typically developing age-matched peer. He imitated simple invisible behaviors best (2.83), with his next best score coming for the category of embedded invisible actions (2.52). The typically developing child (28) imitated simple invisible behaviors and simple emotions at a maximal level (3). His scores were also high for imitation of embedded invisible behaviors and embedded emotion, with imitation of embedded emotion being slightly higher (2.86) than that of embedded invisible actions (2.59). His performance did not decline across categories of behaviors as would have been predicted, but remained fairly stable and high overall.

As a whole these results suggest that the group pattern of performance across imitation tasks mostly holds true for these individual children. Simple invisible behaviors seem to be the easiest to imitate, and performance generally declines as would be expected, if it declines. They also indicate that the older children with ASD in this sample are very capable imitators who often out-perform their age-matched typically developing peers. The younger children with ASD also appear to be slightly worse imitators than their typically developing age-matched peers overall. However, the imprecise matching necessitated by the small sample of children with ASD in this study makes drawing any firm conclusions difficult from this comparison.

Odor intervention for Imitation

I predicted that odor would enhance imitation in younger children and children with ASD. To test whether the odor intervention influenced imitative performance, a separate group of analyses was conducted on imitation score in the odor condition and the no odor condition for the 7 categories of imitation tasks included in the grand analysis of imitation. These imitation categories were: (1) *motor,* (2) *simple emotion,* (3) *embedded emotion,* (4) *simple invisible,* (5) *embedded invisible,* (6) *simple visible,* (7) *embedded visible.* A repeated measures ANOVA was conducted with imitation category and odor condition as the within subjects variables and age and diagnosis as the between subjects variables. There were two significant within subjects interaction effects for odor. There was a significant interaction for Task X Odor, $F(4.24,140.05) = 3.22$, $p = .013$, $\eta^2 = .089$ and for Task X Odor X Age, $F(4.24,140.05) = 2.93$, $p = .021$, $\eta^2 = .082$. Performance on imitations tasks varied according to odor condition and according to odor condition and age (See Figure 20). There were no between subjects effects for this analysis. Overall, imitation varied in the odor condition differently than in the no odor condition and varied among the older and younger children in the odor and no odor conditions differently. As in the grand analysis, there were significant differences in imitation across tasks for age, diagnosis and Age X Diagnosis.

Looking Behavior

There are four categories for which looking time data was collected: (1) *look at mother,* (2) *look at imitation task toys,* (3) *look away,* and (4) *total time spent in tent.* Percent of total time in tent spent gazing in each direction was calculated for visit 1 and visit 2, respectively. I predicted that older children would look at mom and the task toys more and would look away less than the younger children. I made the same prediction for typically developing children relative to children with ASD. I also predicted that the younger children and the children with ASD would take longer to complete the task (longer time in tent) than their older and typically developing peers.

To determine whether pattern of looking behavior differed from visit 1 to visit 2, a repeated measures ANOVA was conducted with percent of looking to each category as the within subjects variable and age and diagnosis as the between subjects variables.

There were significant within subjects effects for looking, $F(1.60, 48.05) = 7.18$, $p = .004$, $\eta^2 = .193$, Looking X Age, $F(1.60, 48.05) = 15.21$, $p = .000$, $\eta^2 = .336$, and Looking X Diagnosis, $F(1.60, 48.05) = 5.67$, $p = .010$, $\eta^2 = .159$. Overall, the children demonstrated different patterns of looking, particularly between age groups and between diagnostic groups (Figure 21). There was also a significant within subjects effect for Looking X Time, $F(1.68,50.29) = 3.55$, $p = .044$, $\eta^2 = .105$, with different patterns of looking time 1 and time 2. There were no significant between subjects effects for looking. There were no differences between or within groups for total in time spent in the tent.

Effect of odor on looking behavior

Next, to test the prediction that the odor intervention would affect looking behavior, a separate group of analyses was conducted on percent of time spent looking at mom, toys and away in the odor condition and in the no odor condition. A repeated measures ANOVA was conducted for each category with percent of total time in tent spent looking at each object and odor condition as the within subjects variables and age and diagnosis as the between subjects variables. There were no significant within subjects effects for odor. There were also no between subjects effects for this analysis. Overall, odor condition did not influence looking behavior.

Relationship between imitation and looking in odor condition

To determine how looking behavior and imitation were related, Pearson bivariate corrections were conducted between all categories of imitation tested in these analyses and percent of time spent looking at mother, toys, and away for the odor and no odor conditions. Regardless of odor condition, percent of time spent looking at mother was always significantly correlated with imitation score for every category of behavior to be imitated and time spent looking away was always significant negatively correlated with imitation score for every category. Thus, the more (proportionally) the children looked at mother, the higher their imitation score and the more (proportionally) the children looked away, the lower their imitation score (see Table 7 for correlations).

Discussion

The results of this study confirm that the ability to imitate is composed of a series of developmental milestones that enable older children to become more advanced imitators than younger children. Tests of imitation require careful construction to be appropriate, in recognition that imitation is not a unitary skill. As such, different aspects of imitation emerge for four and five year old children but are at best very inconsistent for the younger three year olds. A further critical result of this study shows that imitation might be delayed, but is not absent altogether in children with ASD. While confirmation of this result requires retesting with a larger sample, these results suggest that disputes about the skills of children with ASD to imitate are largely based on the utilization of different kinds of tests to measure imitation among varying samples. It is likely that these differences in performance reflect the fact that imitation is not a unitary skill, and do not necessarily indicate a true lack of the ability in children with ASD. This has some implications for applied issues in this area.

One of the principal challenges to constructing a coherent story about imitation in ASD has been the disparate findings that have previously been reported. For example, one research report will indicate no deficits in imitation among individuals with ASD (Charman & Baron-Cohen, 1994), another will suggest impairment in imitation of emotion but not object manipulation (Stone et al., 1997), and yet another will describe impairment in motor imitation of meaningful and meaningless actions but will not directly test imitation of emotion at all (Smith & Bryson, 1998). These different findings are almost certainly a result of the fact that different theoretical perspectives emphasize different aspects of imitation, testing for only those aspects in particular, thus making it difficult to read across the studies and effectively compare the theories. The goal of the current study was to combine a variety of the categories of behaviors previously found to be impaired in children with ASD into one unified measure of imitation such that findings might speak to all theoretical positions, and begin to paint a unified account of the imitative ability of young children with ASD.

Another inconsistency with past work on imitation in ASD has been the scoring methodology used to assess imitation. Past coding systems have been imprecise and have largely looked at overall quality of imitation. For example, prior studies would score a behavior as “partial imitation” but would be unable to describe which part of the action was imitated and which was not. The imitation behaviors in this task were scored in a more objective manner, based on particular features of the behavior being imitated or not, rather than based on a global impression of quality of imitation. Thus, more information became available about what aspects of the behavior might have been more challenging to imitate. In this study, a partial imitation could refer to imitation of any number less than all of the components that make up the task, and the scoring system allows for determination of precisely which components were or were not imitated. Use of this scoring methodology allowed for the analysis of embedded emotional expressions apart from the actions in which they were situated, for instance, a critical analysis that was not previously possible using other scoring procedures.

Most previous studies of imitation have examined groups of children with a wide range of ages (Charman & Baron-Cohen, 1994) or, more recently, have begun to study very young groups of children (Stone et al., 1997). While both sampling strategies are important and provide information about individuals with ASD and how they imitate, they are limited in their ability to address how imitation might progress with development. The current study tested a sample of young children who were very close in age, and comparisons were drawn between (and within) age groups, making the test quite sensitive to differences in imitation, even among children very close in age.

The study of imitation among individuals with ASD is critical because imitation serves as a route for language and social skill acquisition. Further, many theoretical explanations for the deficits related to ASD list imitation as a possible precursor, and thus a predictor, of the eventual diagnosis of ASD. If deficits in ASD can be demonstrated consistently and early, using tests of imitation, such tests might become preliminary indicators of a possible ASD diagnosis. The results of such tests, therefore, might encourage early entry into treatment programs for children with low imitative ability to prevent (or reduce) language and social impairments.

Thirty-two typically developing children and five children with ASD took part in the imitation task created for the current study. Each child participated in the study twice and participation entailed playing an imitation game with mother in a tent constructed for the purposes of this study. The imitation game consisted of 18 tasks (refer to Table 2 for list of behaviors), repeated three times in succession and scoring was based on number of components of the action the child imitated each of the three times it was modeled. During one of the two visits, a very low level of a pleasant odor was present in the tent, to test whether the odor might enhance social motivation to engage in the task and, ultimately, to imitate.

Imitation according to age

One critical question this study addressed was whether older children would be better imitators than younger children. Indeed, the hypothesis that older children would imitate better than younger children was supported. For every category of imitation that was tested, there were differences in performance between the older and younger age groups. The four and five year old children always imitated better than the three year old children, and the age differences nearly always accounted for more of the difference (larger effect size) in imitative performance than the effect related to diagnosis. This finding is not surprising given the cognitive advances that occur around this age (e.g. Theory of Mind) (Baron-Cohen, 1990).

Imitation according to diagnosis

Previous research (Rogers & Pennington, 1991; Smith & Bryson, 1994; Williams et al., 2001) led to the hypothesis that typically developing children would imitate better than children with ASD. This hypothesis was also generally supported. For all categories of behavior except the predetermined invisible behaviors there was a significant between subjects main effect for diagnosis. In all categories of behavior, the typically developing children out-performed the children with ASD overall. Together with the effects for age, this finding further supports Rogers' claim that the ability to imitate is a developmental milestone, and that it might be delayed, but not absent altogether, in children with ASD. In fact, on many of the tasks measured in this study, the older children with ASD performed similarly to the older typically developing children in terms of imitative performance and less like the younger children with ASD. It is precisely those youngest children with ASD who appear most impaired in imitative ability. Further, the relative strength of the effect for diagnosis was nearly always less than that of age for the same behaviors, suggesting that age might be a more prominent factor in producing said differences than ASD, though presence of ASD does influence imitative performance.

Imitation across all tasks

The most important set of results of this study are those of the grand analysis where all categories of behavior were tested at once. By combining all categories of behavior into a single measure, comparisons of performance on all the tasks within and between subjects were possible. Such comparisons revealed that embedded emotion was the hardest-to-imitate category of behavior for all children. Imitation of simple invisible, motor, and simple visible behaviors seemed to be easiest for all children: performance was highest in these categories and performance did not differ among them. Imitation of simple emotion fell in the middle of the performance hierarchy, being easier to imitate than behaviors that included embedded facial expressions but harder to imitate than simple invisible, motor, and simple visible tasks. With the exception of these three easiest-to-imitate behaviors, whose performance was not different from one another, performance among all behavioral categories differed significantly.

Further, there were significant between subjects differences that confirm the above results related to age and diagnosis. These findings intimate an interaction between age and diagnosis wherein older children with ASD can approximate the imitative performance of the older typically developing children across most tasks but the younger children with ASD imitate in a distinctly different way than all other groups. This is extremely telling and has implications for theory and practice, most importantly that early intervention and exposure to skills such as imitation can be hugely beneficial for children with ASD in their ability to develop capabilities. Indeed, all older children with ASD in this sample participate in therapeutic programs that emphasize such skills.

These results recommend taking an all-encompassing approach when studying and reporting about imitative ability in individuals with ASD. Impairments are not uniform across all categories of behavior; some are more impaired than others. Further, the relative importance of the deficits might not be clear if studied in isolation. Although imitation on motor tasks was significantly different between groups according to age and diagnosis, imitative performance of tasks in the motor category was very high for all children and the differences were relatively small and will probably disappear with development. In fact, these data suggest exactly that given that the older children with autism are comparable to the older typically developing children on imitation of motor behaviors. Anecdotally, mothers and teachers reported that simple motor behaviors are among the first to be taught to young children with ASD using traditional instructional methods. It could be that the behaviors that comprise this task were familiar to the children with ASD and so their performance was inflated. If that is the case, it would indicate that such traditional therapies are effective in imparting such skills to the children they aim to serve. On the other hand, the tasks may have been selectively imitated because they could be accomplished and, therefore, the rewarding aspect of the learning became reinforced for the children. It becomes apparent that reports of findings must be presented with an appropriate explanation of their relative significance to create as accurate and applicable picture of imitative abilities in individuals with ASD as possible.

Imitation of Emotion

Hobson and Hobson's and Rogers' research indicated that children with ASD would have specific difficulties imitating emotional expressions. This is an important prediction because emotional expressions have a communicative function as part of daily social interaction. The findings of the current study confirm that imitation of emotion, both simple and embedded, is particularly difficult for children with ASD to imitate. Typically developing children imitated both simple and embedded emotional expressions significantly better than did the children with ASD, and the young children with ASD were the poorest imitators of both simple and embedded emotions. Older children were also significantly better than younger children at imitation of emotion, both simple and embedded, overall. These findings are further evidence that children with ASD, particularly younger children with ASD, are impaired in their ability to imitate emotion.

However, imitation of embedded emotional expressions was the most difficult category of behavior for all children to imitate overall, suggesting that there is something particularly challenging about attending to and reproducing emotion in context, not only for children with ASD but for all young children. This was made explicit in the comparison between imitation of the simple smile and imitation of the embedded smiles, where the embedded smiles were more difficult for all participants to imitate. In that analysis, the older children imitated smiles better than younger children and typically developing children imitated smiles better than children with ASD. However, that there was a difference in imitative performance between types of smile (simple vs. embedded) suggests that, in addition to the emotional nature of the behavior to be imitated, the complexity of the task affects performance. This indicates that a developmental delay, partially cognitive in nature, might account for deficits in the ability to imitate emotional expression specifically. Hobson and Meyer's (2006) and Rogers' (2003) theoretical perspectives are strengthened by these findings.

A further analysis compared imitation of simple emotion to imitation of motor tasks, which did not include long sequential patterns or embedded facial expression, as a test of which kind of simple behavior is more challenging to imitate. Again, these theories would predict that imitation of emotion would be more difficult for children with ASD, and again this was confirmed. Overall, children with ASD were worse at imitation of simple emotion than were typically developing children, though for the older children both tasks were imitated at very high levels. Once again, the group of young children with ASD imitated both simple emotions and simple motor behaviors worst, seeming different from all other children both in difference in imitative ability between the types of tasks, and likely creating the effect for diagnosis with their very low scores. The imitation of simple emotions was more difficult for the young children with ASD, in particular, to imitate. This implies that simple emotions are more difficult to imitate for children with ASD relative to other simple non-affective behaviors and also suggests that there is a developmental progression for learning this skill as well, meaning that older children with ASD can acquire the ability to attend to and imitate simple emotion.

The distinction between imitation of simple and embedded emotions, a distinction put forth by Hobson and Hobson, suggests that, for all children, pairing emotion with context makes deciphering and reproducing the expression more difficult. This has implications for real-life scenarios where emotional expression might be harder for children, especially younger children and children with ASD, to attend and react to in the context of conversation and daily activity. Consequently, special attention should be paid to teaching emotional expression to children with ASD, especially within an interactive context. Emotional expressions are more difficult for children, particularly young children with ASD, to imitate than are simple behaviors that do not involve many steps and that do not included embedded facial displays. Emotional expressions also possess a special, communicative function that is valuable for social interaction. Therefore, it is particularly important to be able to recognize and display emotional expressions, so that the full meaning of what is being conveyed in a social interaction might be understood. Moreover, when emotional expressions are embedded within the context of action, the task becomes even more difficult for all children, again especially for younger children and children with ASD. Typically developing children have strategies for processing interactions that allow them to learn these display rules, even in a more complex situation. Children with ASD, however, have been said to be impaired in their ability to do so. While the results of this study suggest that older children with ASD can learn these skills, their abilities are still deficient relative to those of their typically developing peers. Thus, emphasizing attention to and appropriate display of emotional expressions in context is crucial for these young children with ASD so that they can fully and appropriately participate in social interactions.

Imitation of sequences

There is reason to believe that sequences of behaviors are more difficult for individuals with ASD to imitate than are singular actions (Williams et al., 2001). Several sequences of behaviors were included among the 18 behaviors that comprised this imitation task. I predicted that sequences would be more difficult for all children to imitate, particularly the younger children and the children with ASD. Given constraints of task design, namely that all behavioral sequences also included embedded facial displays, this was difficult to test directly and, in the absence of the facial display confound. Although a distinction cannot be made between number of components included in the behavior (sequence) and inclusion of embedded facial expression with the behavior, the combination of these factors certainly creates more complexity among the tasks to be imitated. There are two related sets of findings that suggest that these more complex tasks are more difficult for children to imitate.

The first set of analyses makes comparisons among tasks within specific categories of behavior that include sequences and embedded facial expressions. There were significant within subjects effects for task for the invisible, visible, expected toy manipulation, and unexpected toy manipulation categories. In each instance, there was one task that was performed differently than the others in that category. For the invisible actions, the different behavior was *open and close mouth*, which was performed at a higher level than *pull earlobe and gasp* and the *rub chin sequence* were. *Open and close* mouth is a simple action comprised of one behavioral component and no embedded emotion so it is not surprising that it was easier to imitate than the other behaviors, which involved more components and embedded emotion. For the visible actions, the *rub finger sequence* was different than the *timeout with O-face* and the *raspberry* actions. Performance on the *rub finger sequence* was lower than the others and it contained five components whereas the others were comprised of four components. For the expected and unexpected toy manipulations, the manipulations involving the toy truck were different from the other two in each category. For the expected manipulations in particular, the *roll truck behavior* was the most predictable use of the toy, and it did not involve an embedded emotion. The other two expected toy manipulations involved embedded emotion.

It appears that within these categories, the more complex tasks – sequences with more steps or those that include embedded facial expression – were more difficult to imitate. This is not surprising and again supports Rogers and Penningtons's (1991) theoretical position that both cognitive and emotional processes contribute to deficits in ASD in a developmentally appropriate progression. In other words, from a developmental perspective, it is completely predictable that simple actions, motor and vocal alike, will be produced before more complex actions. That the same holds true for imitation is unsurprising.

Alternately, it could be that some of the tasks were more familiar, or even practiced, and thus were easier for children to imitate. This might be particularly true for the tasks involving the truck, a more common toy that all children were likely to have had some experience with than the others. It is impossible to say whether this is the case for sure because no measure of task familiarity was included in the current study. However, as with the motor tasks, it could be that previous exposure to the behavior inflated imitative performance apart from any feature of the task itself. If this held true, the efficacy of experience and exposure to impart skills and knowledge to children, including children with ASD, would again be substantiated and therapies and interventions that provide such opportunities for children with ASD would be championed.

There are implications for imitation task design that arise from these findings as well. Measures of imitative ability should be sensitive to task complexity and should ideally be comprised of tasks of a range of complexities. In fact, if the same tasks could be included in the task in a simple and then in a more complex manner, direct comparisons could be made that would provide more information about task complexity. Similarly, if the same tasks could be incorporated into the measure with and without embedded facial expressions, a direct assessment of the effect of the embedded expression could be made. Both kinds of tests would provide insight for what makes tasks especially challenging and might suggest approaches for teaching these behaviors. For example, if embedded expressions are more difficult, tasks that require such expression could be taught first without the expression and the expression component could be added to the routine once the first part has been mastered.

The visible and invisible tasks were also broken into sets of simple behaviors, with few components and no embedded facial expression, and embedded behaviors, which included facial expressions and, often, more components. The embedded behaviors were examined including, and then again excluding the facial expression. There were no differences in results between these types of analyses, suggesting that the complexity of the task does affect imitation. However, because all tasks were observed and, ideally imitated with the expression embedded, no distinction can be made about the relative contribution of facial expression or number of components in increasing task complexity.

Odor as social motivation intervention

A unique exploratory aspect of this study was the use of pleasant odor as a social motivation tool. There is reason to believe that children with ASD and younger children might benefit from positive motivation. This is likely the case, especially for children with ASD, given their unusual engagements patterns. Children with ASD seem unmotivated by social interaction and, often, will attend or share only as much as is necessary to perform a task, preferring to focus their attention on objects to be manipulated rather than an interaction partner (Hobson & Hobson, 2007). There is also reason to believe that odor might function as a social motivator and create a more positive affective experience for these children that they would otherwise not have experienced given their inattentiveness to facial displays of affect of their interaction partners (Ashby, et al., 1999).

I predicted that odor would enhance imitative performance, especially for the younger children and the children with ASD. Analyses revealed significant within subjects effects for task performance relative to odor condition and odor condition and age together. Overall, imitation varied in the odor condition differently than in the no odor condition and varied among the older and younger children in the odor and no odor conditions differently. For older children, easier tasks were imitated better in the presence of odor (simple invisible, motor, and simple visible tasks) while the harder-to-imitate tasks were performed better in the no odor condition. For younger children, simple emotions were imitated better in the no odor condition but all other behaviors were imitated better in the odor condition. Thus, odor appears to have supported the younger children in their ability to imitate overall. Odor did not interact with diagnosis in either case, leaving the prediction that children with ASD would be most helped by the presence of odor unsupported.

While the effect of odor on the imitative performance of the children was small, especially for the older children, the fact that odor influenced imitation at all is impressive. This provides some evidence that creating a supportive environment can enhance imitative performance among children. For older children, this is especially true when they already are competent (perhaps overly competent) to perform the task. It could be that the older children performed at such a high level overall that performance was unlikely to be enhanced, especially where tasks were more challenging. Perhaps imitation of easier tasks could be improved with slight increases in attending but imitation of harder tasks would require a stronger intervention. The younger children, however, seemed to benefit most when imitating the more challenging behaviors, possibly because it was more difficult for them to attend to all features of the task and the odor helped enhance attending overall. These results call for further research to examine the effect of environmental supports on performance and mood regulation, a new and exciting line of inquiry.

Looking behavior

There was also reason to believe that looking behavior (attention) might differ, especially for children with ASD. As stated above, children with ASD seem less motivated by social interaction and do not seem to find reward in interacting in the same way that their typically developing age mates do. Therefore, their patterns of attending to social interaction partners are often different, with less time spent looking at people and more time spent looking at objects (Hobson & Hobson, 2007). Thus, there is reason to believe that children with ASD might look at mother less and might spend more time looking at the toys associated with the task or looking away from the task altogether.

The differences in looking behavior found in this study indicate that the looking behavior of younger children with ASD is different, more disorganized, than the other three groups of children. With regard to pattern of looking, older children with ASD most resemble younger typically developing children while older typically developing children and younger children ASD have distinctive patterns of looking, with younger children with ASD being the most different and seemingly disorganized (Figure 16). Specifically, older typically developing children looked at mother proportionally longer than other groups of children; younger children with ASD looked at mother least. Younger children with ASD looked away proportionally longer than other groups; older typically developing children looked away least. There were no striking differences apparent with regard to looking at the toys.

I also predicted that odor would increase looking and decrease looking away. This prediction was completely unsupported by the data. Odor did not influence looking behavior. In fact, imitation scores were related to looking behavior in the same way in both the odor and no odor condition. Overall, higher imitation scores were related to a higher proportion of time spent looking at mother and a lower proportion of time spent looking away.

If pattern of looking during the imitation task is adaptive, then we must presume that the top imitators, the typically developing older children, have the most advanced strategy for attending. If this is the case, then it would appear that the younger children with ASD are the furthest from this adaptive behavior pattern, having not yet learned how to direct attention for maximal benefit. The older children with ASD seem to be delayed in developing these strategies, demonstrating looking patterns most like the younger typically developing children. Again, this suggests a delayed development of strategies and abilities that contribute to overall imitative performance. Further, these findings suggest that interventions should teach strategies for attending in various situations, helping children with ASD to recognize important and useful information present in the different scenarios. This seems to be a function that is difficult and takes longer to progress for this group of children. Research around imitation in ASD, and other such skills that require these sorts of adaptive functions, should consider such factors when reflecting on and presenting implications for their results. It is possible that differences in imitative ability can be partially attributed to differences in behavior not measured by most imitation measures. For example, it is possible that an individual with ASD might score lower on imitation tasks because they attended to less of the information the model was demonstrating and, therefore, they imitate what they gleaned from the scenario, an incomplete representation of what was presented.

Repeated measures design

The repeated measures design of the current study enabled a comparison to be made between performance at time 1 and performance at time 2. Overall, imitative performance held steady or improved from time 1 to time 2. In particular, imitation of motor behaviors and visible behaviors was significantly improved at time 2. Analysis of type of symbolic behavior (symbolic or non-symbolic) showed significant effects for time as well; again, performance at time 2 was improved compared to that at time 1. These results suggest that early and repeated exposure to tasks that will likely be most difficult for young children with ASD can optimize learning and skill acquisition.

Other theoretical implications

The current study can speak to the delayed, but eventual, development of imitation in ASD because it compared groups by age and diagnosis. The older children with ASD imitated better than the younger children with ASD. Older children also imitated better than younger children overall, suggesting that this trend holds true for typically developing children as well. This indicates that imitation is not impossible for these children and that these abilities improve over time, as would typically be expected with development, just at a slower pace for children with ASD. Younger children with ASD are certainly impaired in their ability to imitate relative to older children with ASD and to typically developing children of their same age, which implies that imitation may indeed be an indicator that ASD could be developing in young children. Thus, theories that situate imitation as such might be on target. However, no theory has been able to fully encompass, describe or explain the deficits of ASD, specifically with regard to imitation, and so more comprehensive investigations are called for to unify past work and create a more complete understanding of the impairments associate with ASD.

The Theory of Mind hypothesis was not tested in the current study. However, the results do suggest that there is a cognitive aspect to the impairments of ASD. Whether ToM is the explanation for these deficits remains controversial, but the theoretical proposition that a cognitive dysfunction is responsible for ASD received some support. Neither was the Mirror Neuron system directly tested in this study. However, high imitation scores on the invisible category of behavior, those that the children could not see themselves performing, suggests that this system is functional in the children in this sample. Otherwise, the children would not have understood or been able to reproduce the actions they were observing, such as rub your chin then rub your head. These results also cast doubt onto Hobson and Hobson's theory that individuals with ASD have more difficulty with self-referential actions (2007). The simple invisible actions were the easiest to imitate for all groups of children in the study and the embedded invisible actions, while more difficult, were not the most difficult to imitate. Not being able to see oneself perform an action and the requirement to touch or reference one's own body as part of an action were not specific impairments for children with ASD tested in this sample.

It is unlikely the motor impairment is uniquely impaired in individuals with ASD. That the older children with ASD imitated at a level that approximated (or in a few cases surpassed) the imitative ability of typically developing older children overall suggests that motor function is in tact in these children. Only one category of behavior, simple emotion, did not include motor behaviors and imitation performance was similar for simple emotions and for the other categories of behavior. Alternately, the fact that the older children with ASD were still impaired on most categories of imitation relative to their older typically developing peers might suggest a modest motor impairment that extends across the board, and that becomes more difficult to overcome as tasks become more complex. This would be difficult to test directly, however, as almost all behavior requires motor function to some extent and so it would be difficult to isolate behaviors that do not require motor function to compare to those that do.

Implications for future testing

A critical caveat applies to all of these findings. There was a very small group of children with ASD included in this study. These children were extremely difficult to recruit and this study ended up with a total sample of five children with ASD, two of whom were younger and three of whom were older. While the above findings suggest trends related to diagnosis, they should be taken with caution. More testing with larger numbers of children with ASD is essential to ensure generalizability of these results. Such future tests are likely to have similar results for the group of typically developing children but might find that imitation scores for the older group of children with ASD decrease slightly and imitation scores for the younger group of children with ASD increase slightly. This would probably be the case given the different levels of impairment seen in all children with ASD, and the differing levels of impairment represented in the sample in this study.

No two children are affected in precisely the same way by ASD and levels of impairment can be quite variable. In the current sample, the older children with ASD were relatively similar while the two younger children with ASD were more dissimilar in features of ASD and in imitative performance. Thus some of the difference between the youngest group of children with ASD compared to the other groups can be accounted for by the performance of the most affected young child with ASD, who was non-verbal and who had just begun his therapeutic intervention. Adding more children to the sample would even out these differences a bit and reign in the variability, which was often quite high. However, ASD is quite a variable and dynamic system and a person with ASD might be more unlike another individual with ASD than he is unlike his typically developing neighbor and so speaking to all individuals who live on the autistic spectrum is a nearly impossible feat.

This has implications for all research involving children with ASD with regard to sample selection and report of findings. First, samples should be carefully selected and the selection process and the sample should be fully described in the research report. Degree of impairment represented in the sample should also be described. Perhaps samples of differently impaired individuals should be created and comparisons between groups should be made. Reports of research findings should also reflect attention to the sample measured. When a sample is particularly high-functioning, with little obvious impairment, this should be made clear in the report and applications and generalizations should be restricted to those children represented by the sample. The large, diverse population of individuals who carry a diagnosis of ASD makes the study of ASD uniquely challenging and necessitates the use of caution when speaking about the generilzability of findings, in recognition of the dynamic nature of ASD and its varying impact on individuals.

Replication of these findings using this imitation measure would confirm the utility of the imitation task overall as a useful and accurate indicator of imitative ability in young children both with and without ASD. The comprehensiveness of the behavioral categories, and the precise, objective method of the scoring system used in this measure make it advantageous relative to past measures. Replication is also needed with more children with ASD, children who represent older and younger age groups and many levels of impairment. First, this will speak to the reliability of the task – do patterns of similar findings emerge through these replications between and among groups? Second, it will allow for a fuller picture of imitative ability in ASD to surface, one that addresses many theoretical perspectives at the same time. There are some refinements of the measure should be attended to when it is re-tested.

First, future studies should incorporate a category of behavioral sequences that does not include embedded facial expression to directly test whether the sequential nature of the task affects performance above and beyond the effects of embedded expression demonstrated here. Ideally, these tasks would be the same, performed once with no facial expression and once including an embedded expression to allow for the most accurate and direct comparisons to be made. Further, the simple emotional expressions strategically included in the measure should be paired with some sequences of behaviors so that comparisons can be drawn between emotions other than smile (such as stick out tongue and frown). Incorporation of positively and negatively valenced emotional expressions, and expressions with and without vocalizations, would also address whether any of these factors make emotional expression more difficult to imitate.

The object manipulation tasks included in this study might also be redesigned. The expected and unexpected categories of behavior would benefit from the inclusion of tasks that are clearly expected or unexpected. The object manipulations in the current task, with the exception of rolling the truck, could all be said to be somewhat unexpected, or less familiar, to these children. Another key addition to future studies using this measure would thus be an assessment of familiarity of the participants with the objects to be manipulated, and with the tasks overall. This would clarify whether prior knowledge of the toy or prior experience performing an action artificially inflated imitation scores.

Future studies of imitation should also adopt a repeated measures or a longitudinal design so as to account for differences that might decrease with development and or practice. Results of this study suggest that imitative ability can improve over relatively brief periods of time as tasks become more familiar and/or more practiced. Stone et al. tested young children with ASD twice, with approximately 1 year between visits. Those children demonstrated improvements in motor skills (as assessed with the Motor Imitation Scale) between the age of 2 and 3 years (1997). Future research should address this issue of improvement over time by using repeated measures, within subjects designs. Some questions related to these improvements remain. Do all categories of behavior improve? Does imitation improve at the same rate or with equal practice/exposure for older and younger children and for children with ASD and typically developing children? Do any behaviors seem to become more difficult to imitate over time?

Conclusion

Rogers & Pennington (1991) were probably on target in suggesting that both cognitive and affective impairments are central deficits in children with ASD, and these impairments interact, each contributing to greater deficits in the other. This was clearly supported by the findings of this study, the results of which emphasize the need to identify ASD early and begin exposing these children to empirically supported therapeutic techniques as early as possible to optimize their learning and to make the most impact on their acquisition of skill. This study also reinforces the need to approach research questions, especially research questions around ASD, broadly, using theory as a guide but with the ultimate goal of obtaining results that have real-world applicability. A more complete picture of the imitative abilities of young children with ASD, relative to their typically developing peers of the same age, emerged in this study by examining the issue from multiple theoretical perspectives at once.

Table 1. Participants with ASD matched with typically developing participants for age and Peabody score

Subject Number	Gender	Odor	Age	Peabody Score	Ethnicity	Number siblings	Birth Order	Mom Age	Mom Education
1111	Male	First	36		White	0	Only	41-45	Coll Deg.
1912	Male	First	41		White	1	Young	46-50	Some Coll
1711	Male	First	54	62	White	1	Oldest	36-40	Coll Deg.
3612	Male	First	53	54	Other	2	Young	41-45	Coll Deg.
2721	Male	Second	58	71	White	2	Twin	36-40	Post Grad.
0222	Male	Second	60		White	6	Middle	36-40	Coll Deg.
2921	Male	Second	62	81	White	1	Oldest	31-35	Coll Deg.
2822	Male	Second	58	73	White	2	Twin	36-40	Post.Grad
3421	Male	Second	47	49	Other	1	Twin	41-45	Coll Deg.
2322	Male	Second	48	51	Hispanic	2	Twin	41-45	Coll Deg.

* shaded indicates children with ASD

Table 2. Imitation behaviors listed by category

BEHAVIOR	COLOR	CATEGORY	OTHER
Smile	Yellow	Emotion	
Tongue out	Yellow	Emotion	
Frown	Yellow	Emotion	
Pull earlobe and gasp	Blue	Invisible gesture	
Open/close mouth	Blue	Invisible gesture	Meaningless gesture
Rub chin, rub head, rub chin	Blue	Invisible gesture	Sequence Meaningless gesture
Time out sign with O face	Pink	Visible gesture	
Hands up, palms out with raspberry	Pink	Visible gesture	
Rub fingers together, clap, rub fingers	Pink	Visible gesture	Sequence Meaningless gesture
Touch head	White	Motor	Motor
Reach	White	Motor	Motor
Open/close hand	White	Motor	Motor
Dice in cup, shake, roll	Purple	Use toy in familiar way	Sequence
Hold up toy, squeak, say HAHA	Purple	Use toy in familiar way	
Roll truck and say Vroom	Purple	Use toy in familiar way	
Dice in cup, shake, drink	Green	Use toy in unfamiliar way	Sequence
Hold toy, rock like baby, Coo	Green	Use toy in unfamiliar way	
Bang truck and Growl	Green	Use toy in unfamiliar way	

Table 3. Statistics for motor task within subjects interactions

Tests of Within-Subjects Effects for Motor Category

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Motortask	1.885	2	.943	7.142	.002	.178
motortask * age	1.648	2	.824	6.245	.003	.159
motortask * diagnosis	2.254	2	1.127	8.540	.001	.206
motortask * age * diagnosis	1.200	2	.600	4.545	.014	.121
Error(motortask)	8.710	66	.132			
Time	1.084	1	1.084	23.421	.000	.415
time * age	.207	1	.207	4.478	.042	.119
time * diagnosis	.551	1	.551	11.911	.002	.265
Error(time)	1.527	33	.046			
motortask * time	.955	2	.477	4.490	.015	.120
motortask * time * age	.713	2	.357	3.353	.041	.092
motortask * time * diagnosis	.923	2	.461	4.340	.017	.116
Error(motortask*time)	7.018	66	.106			

Table 4. Means for imitation of symbolic tasks – total, by age, and by diagnosis

age	diagnosis		smile	tongue	frown	rock toy	timeout	Raspberry	Roll truck	drink dice
1	1	Mean	2.78	2.83	2.55	2.12	2.41	2.48	2.73	2.10
		N	15	15	15	15	15	15	15	15
		Sd. Dev	.42	.52	.64	.70	.49	.68	.34	.30
	2	Mean	1.63	2.00	1.38	1.44	1.31	1.19	2.13	.95
		N	2	2	2	2	2	2	2	2
		Sd. Dev	1.24	.71	1.24	1.33	1.50	.97	.53	.35
	Total	Mean	2.65	2.74	2.42	2.04	2.28	2.32	2.65	1.96
		N	17	17	17	17	17	17	17	17
		Sd. Dev	.63	.59	.78	.77	.70	.80	.40	.48
2	1	Mean	2.99	2.99	2.96	2.42	2.87	2.74	2.85	2.51
		N	17	17	17	17	17	17	17	17
		Sd. Dev	.06	.06	.13	.74	.37	.54	.28	.29
	2	Mean	2.92	3.00	2.58	2.71	2.46	2.25	2.92	2.43
		N	3	3	3	3	3	3	3	3
		Sd. Dev	.14	.00	.72	.31	.31	.65	.14	.15
	Total	Mean	2.98	2.99	2.90	2.46	2.81	2.66	2.86	2.50
		N	20	20	20	20	20	20	20	20
		Sd. Dev	.08	.06	.30	.70	.39	.57	.26	.27
Total	1	Mean	2.89	2.91	2.77	2.28	2.65	2.61	2.79	2.32
		N	32	32	32	32	32	32	32	32
		Sd. Dev	.30	.36	.49	.73	.49	.61	.31	.36
	2	Mean	2.40	2.60	2.10	2.20	2.00	1.83	2.60	1.84
		N	5	5	5	5	5	5	5	5
		Sd. Dev	.95	.65	1.04	.99	1.00	.89	.52	.84
	Total	Mean	2.82	2.87	2.68	2.27	2.56	2.51	2.77	2.25
		N	37	37	37	37	37	37	37	37
		Sd. Dev	.46	.42	.61	.75	.61	.70	.34	.47

Table 5. Means for imitation of non symbolic tasks – total, by age, and by diagnosis

age	diagnosis		Touch head	Reach	Open/close hand	Open mouth	Pull earlobe	Rub chin sequence	Rub finger sequence	Roll dice	Bang truck
1	1	Mean	2.82	2.87	2.66	2.68	2.39	1.95	1.91	2.32	2.35
		N	15	15	15	15	15	15	15	15	15
		Std. Dev	.52	.287	.52	.58	.63	.645	.73	.28	.54
	2	Mean	2.83	1.63	1.92	2.38	1.25	1.25	.80	1.50	1.56
		N	2	2	2	2	2	2	2	2	2
		Std. Dev	.24	1.24	1.53	.88	.53	.92	.85	.71	.44
	Total	Mean	2.82	2.72	2.57	2.65	2.26	1.86	1.78	2.22	2.26
		N	17	17	17	17	17	17	17	17	17
		Std. Dev	.49	.58	.67	.59	.71	.69	.80	.42	.58
2	1	Mean	2.92	3.00	2.91	2.90	2.64	2.63	2.63	2.59	2.87
		N	17	17	17	17	17	17	17	17	17
		Std. Dev	.32	.00	.18	.30	.34	.41	.33	.40	.17
	2	Mean	2.89	2.75	2.89	3.00	2.50	2.87	2.07	2.33	2.83
		N	3	3	3	3	3	3	3	3	3
		Std. Dev	.19	.25	.10	.00	.43	.23	1.12	.209	.289
	Total	Mean	2.92	2.96	2.91	2.91	2.62	2.67	2.55	2.55	2.86
		N	20	20	20	20	20	20	20	20	20
		Std. Dev	.30	.12	.17	.27	.35	.39	.51	.39	.18
Total	1	Mean	2.88	2.94	2.79	2.80	2.52	2.31	2.29	2.46	2.63
		N	32	32	32	32	32	32	32	32	32
		Std. Dev	.42	.20	.40	.46	.50	.63	.65	.37	.46
	2	Mean	2.87	2.30	2.50	2.75	2.00	2.22	1.56	2.00	2.33
		N	5	5	5	5	5	5	5	5	5
		Std. Dev	.19	.89	.94	.56	.80	1.01	1.13	.60	.76
	Total	Mean	2.87	2.85	2.75	2.79	2.45	2.30	2.19	2.40	2.58
		N	37	37	37	37	37	37	37	37	37
		Std. Dev	.40	.41	.492	.46	.57	.67	.76	.43	.51

Table 6. Pairwise comparisons for every category of behavior included in the grand analysis

Category	**Compared to**	**t-value**	**df**	**significance**
Simple Invisible	Motor	.180	36	.858
Simple Invisible	Simple Visible	.547	36	.587
Simple Invisible	Simple Emotion	2.20	36	.034*
Motor	Simple Visible	1.03	36	.311
Motor	Simple Emotion	2.49	36	.017*
Simple Visible	Simple Emotion	2.187	36	.035*
Simple Emotion	Embedded Visible	2.41	36	.021*
Simple Emotion	Embedded Invisible	4.26	36	.000*
Simple Emotion	Embedded Emotion	8.45	36	.000*
Embedded Visible	Embedded Invisible	2.33	36	.026*
Embedded Visible	Embedded Emotion	7.32	36	.000*
Embedded Invisible	Embedded Emotion	5.35	36	.000*

* indicates a significant difference in imitation score for the behaviors compared

Table 7. Correlations for all categories of behavior with percent of looking time in odor

Correlations

		momodor	toysodor	awayodor
motorodor	Pearson Correlation	.620**	.249	-.610**
	Sig. (2-tailed)	.000	.143	.000
	N	36	36	36
pinkodor	Pearson Correlation	.714**	.066	-.707**
	Sig. (2-tailed)	.000	.701	.000
	N	36	36	36
purpleodor	Pearson Correlation	.468**	.191	-.558**
	Sig. (2-tailed)	.004	.265	.000
	N	36	36	36
greenodor	Pearson Correlation	.585**	.334*	-.665**
	Sig. (2-tailed)	.000	.047	.000
	N	36	36	36
simpinvisodor	Pearson Correlation	.458**	.158	-.384*
	Sig. (2-tailed)	.005	.357	.021
	N	36	36	36
embedinvisodor	Pearson Correlation	.710**	.101	-.700**
	Sig. (2-tailed)	.000	.557	.000
	N	36	36	36
simpvisodor	Pearson Correlation	.611**	.249	-.637**
	Sig. (2-tailed)	.000	.143	.000
	N	36	36	36
embedvisodor	Pearson Correlation	.718**	.198	-.759**
	Sig. (2-tailed)	.000	.246	.000
	N	36	36	36
symodor	Pearson Correlation	.697**	.249	-.720**
	Sig. (2-tailed)	.000	.143	.000
	N	36	36	36
simpemotodor	Pearson Correlation	.527**	.216	-.521**
	Sig. (2-tailed)	.001	.206	.001
	N	36	36	36
embedemotodor	Pearson Correlation	.726**	.024	-.672**
	Sig. (2-tailed)	.000	.887	.000
	N	36	36	36
momodor	Pearson Correlation	1.000	-.180	-.781**
	Sig. (2-tailed)		.295	.000
	N	36.000	36	36
toysodor	Pearson Correlation	-.180	1.000	-.282
	Sig. (2-tailed)	.295		.096
	N	36	36.000	36
awayodor	Pearson Correlation	-.781**	-.282	1.000
	Sig. (2-tailed)	.000	.096	
	N	36	36	36.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 8. Correlations for all categories of behavior with percent of looking time in no odor

		momnoodor	toysnoodor	awaynoodor
motornoodor	Pearson Correlation	.572**	-.140	-.434*
	Sig. (2-tailed)	.000	.431	.010
	N	34	34	34
pinknoodor	Pearson Correlation	.696**	-.222	-.646**
	Sig. (2-tailed)	.000	.206	.000
	N	34	34	34
purplenoodor	Pearson Correlation	.665**	-.105	-.514**
	Sig. (2-tailed)	.000	.555	.002
	N	34	34	34
greennoodor	Pearson Correlation	.571**	-.002	-.458**
	Sig. (2-tailed)	.000	.990	.006
	N	34	34	34
simpinvisnoodor	Pearson Correlation	.377*	-.062	-.244
	Sig. (2-tailed)	.028	.729	.163
	N	34	34	34
embedinvisnoodor	Pearson Correlation	.585**	-.139	-.574**
	Sig. (2-tailed)	.000	.431	.000
	N	34	34	34
simpvisnoodor	Pearson Correlation	.561**	-.137	-.444**
	Sig. (2-tailed)	.001	.440	.009
	N	34	34	34
embedvisnoodor	Pearson Correlation	.757**	-.183	-.621**
	Sig. (2-tailed)	.000	.301	.000
	N	34	34	34
symnonodor	Pearson Correlation	.656**	-.048	-.580**
	Sig. (2-tailed)	.000	.786	.000
	N	34	34	34
nonsymnoodor	Pearson Correlation	.704**	-.237	-.598**
	Sig. (2-tailed)	.000	.177	.000
	N	34	34	34
simpemotnoodor	Pearson Correlation	.537**	-.051	-.507**
	Sig. (2-tailed)	.001	.773	.002
	N	34	34	34
embedemotnoodor	Pearson Correlation	.704**	-.282	-.545**
	Sig. (2-tailed)	.000	.106	.001
	N	34	34	34
momnoodor	Pearson Correlation	1.000	-.486**	-.766**
	Sig. (2-tailed)		.004	.000
	N	34.000	34	34
toysnoodor	Pearson Correlation	-.486**	1.000	.097
	Sig. (2-tailed)	.004		.583
	N	34	34.000	34
awaynoodor	Pearson Correlation	-.766**	.097	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 1. Motor behavior within subjects main effect for task

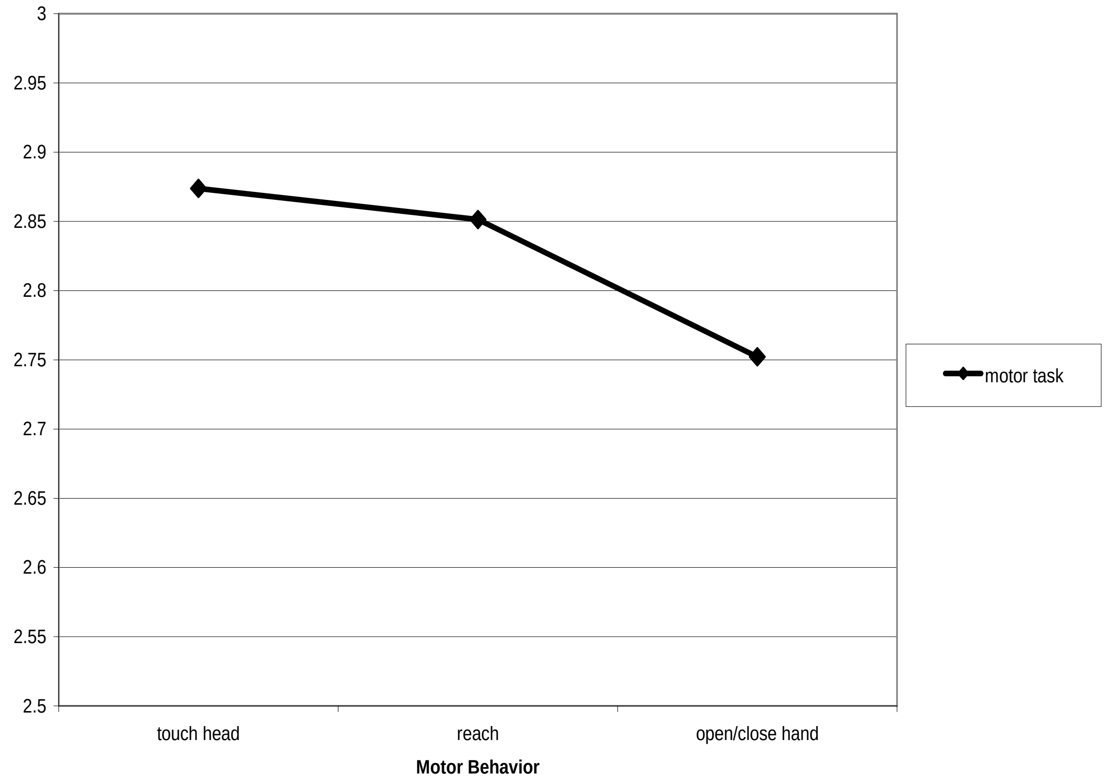


Figure 2. Simple imitated emotion within subjects effect for task

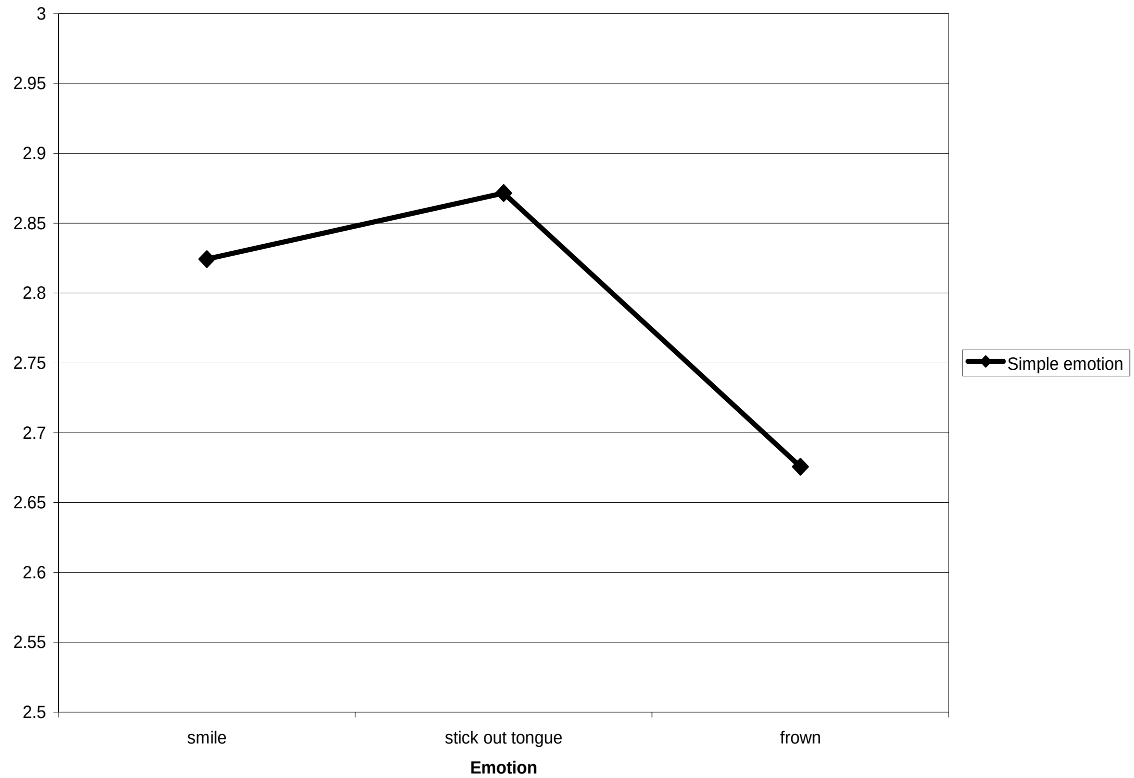


Figure 3. Simple imitated emotion age X diagnosis between subjects interaction

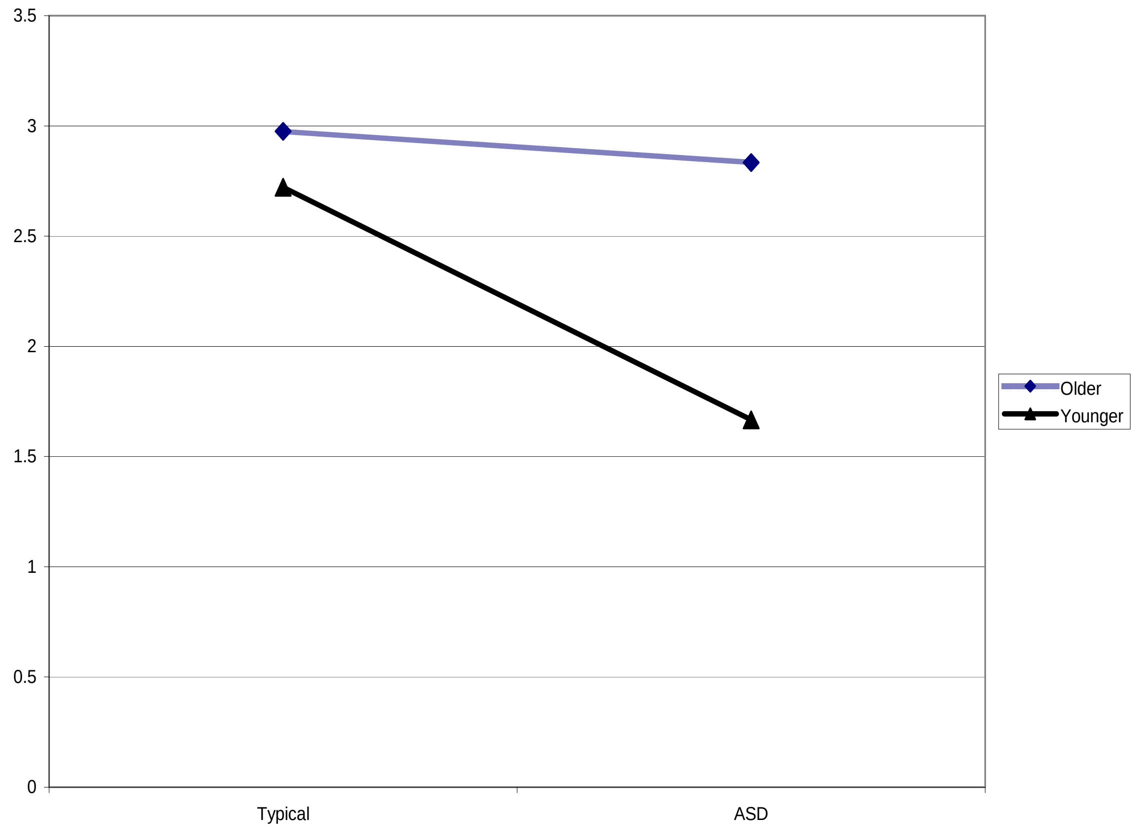


Figure 4. Embedded emotion within subjects effect for time (+/- SD)

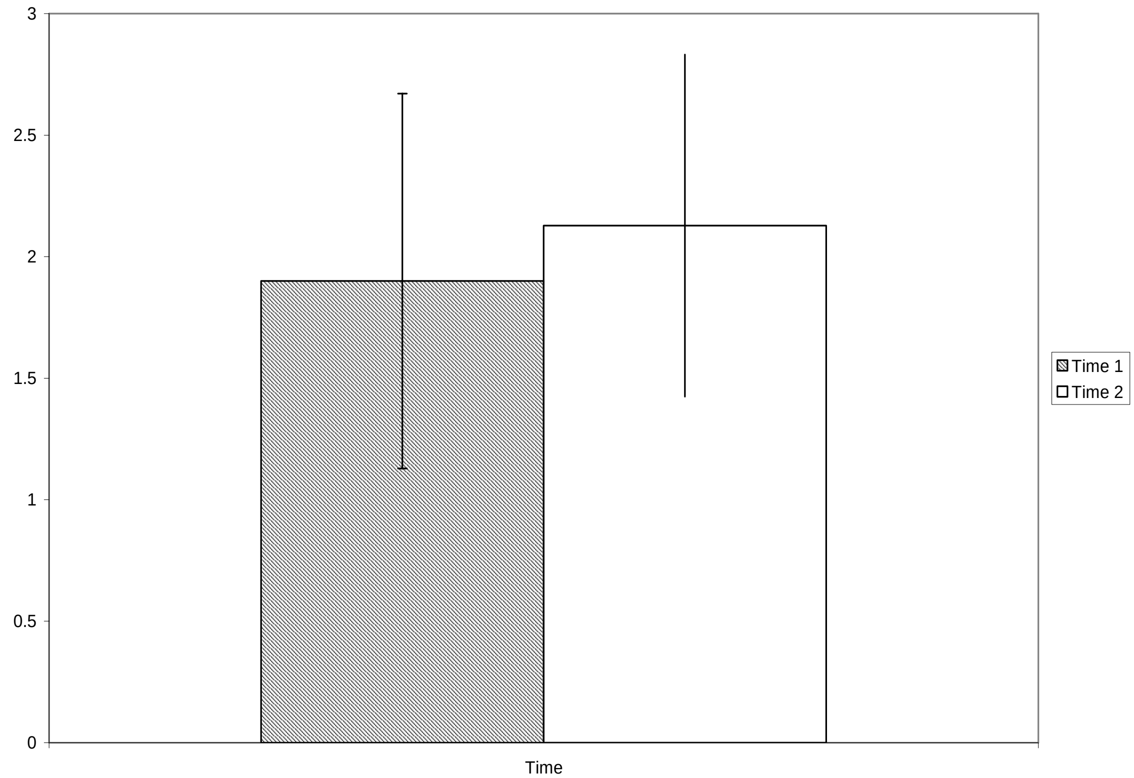


Figure 5. Type of smile within subjects main effect for smile (+/- SD)

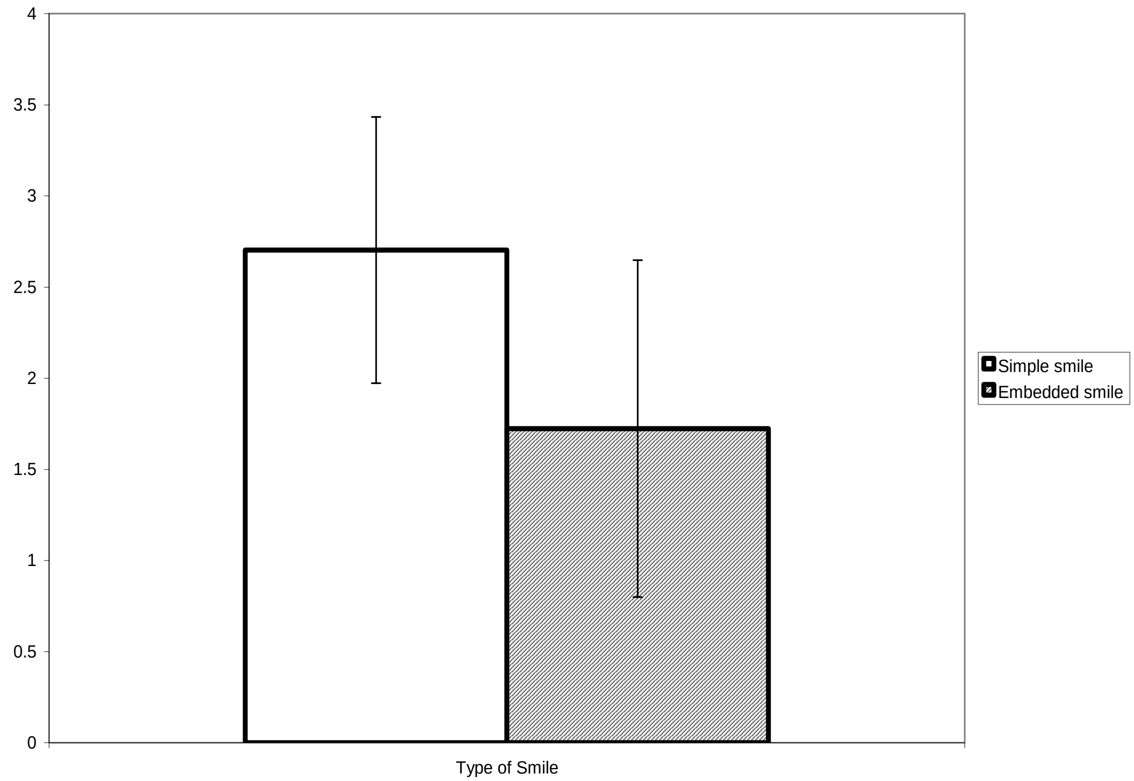


Figure 6. Simple imitated emotion vs. motor behaviors within subjects interaction for task X diagnosis

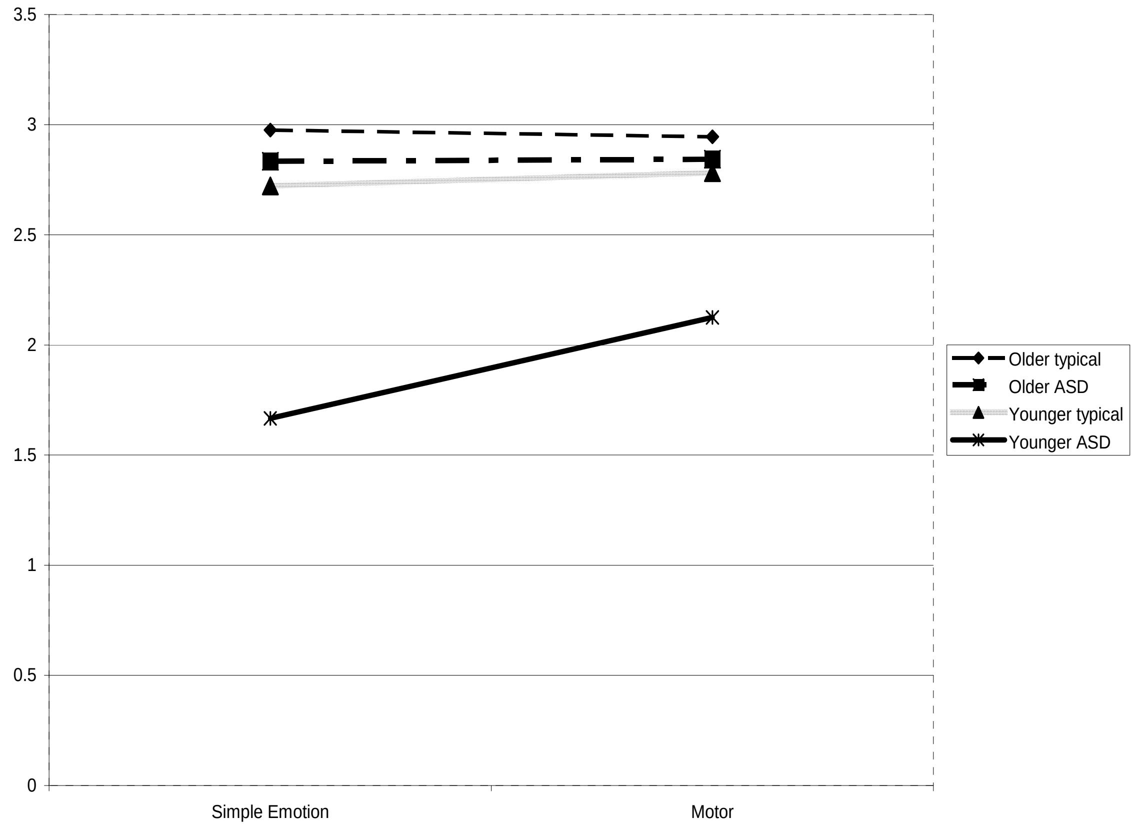


Figure 7. Invisible behavior within subject interaction for task X age

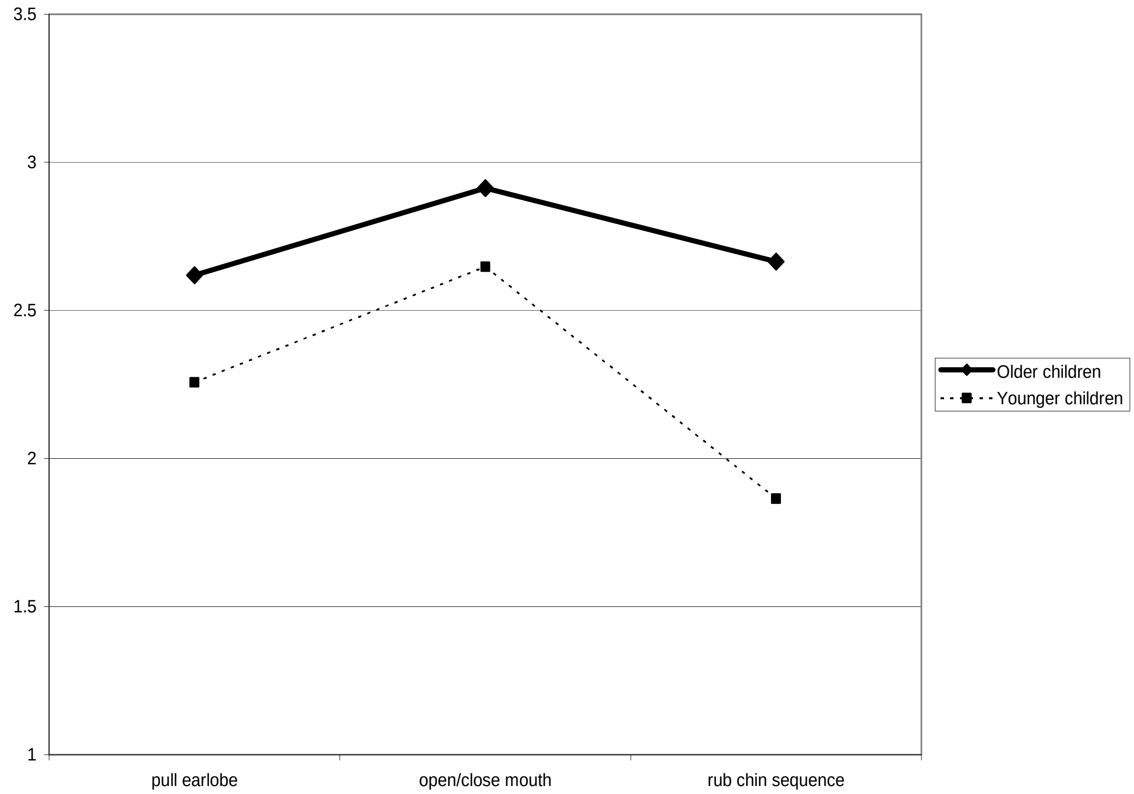


Figure 8. Visible tasks within subjects main effect for task

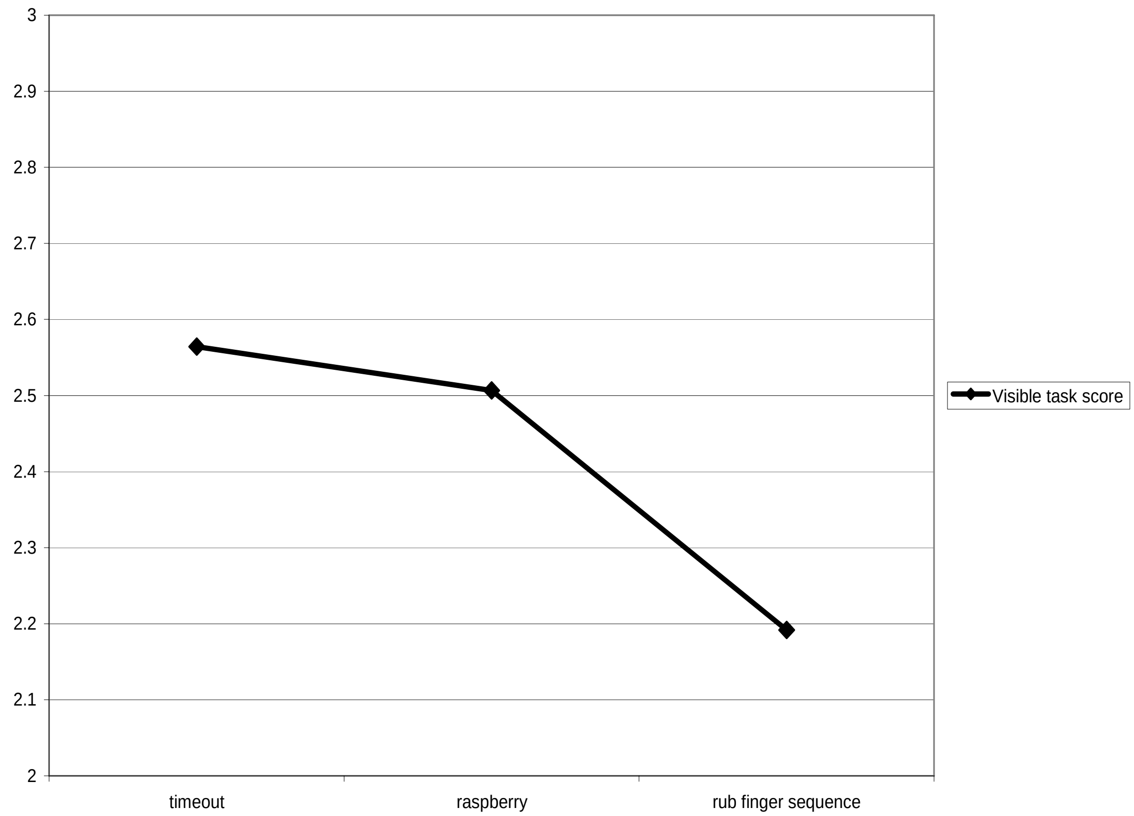


Figure 9. Embedded visible behavior within subjects interaction for task X time

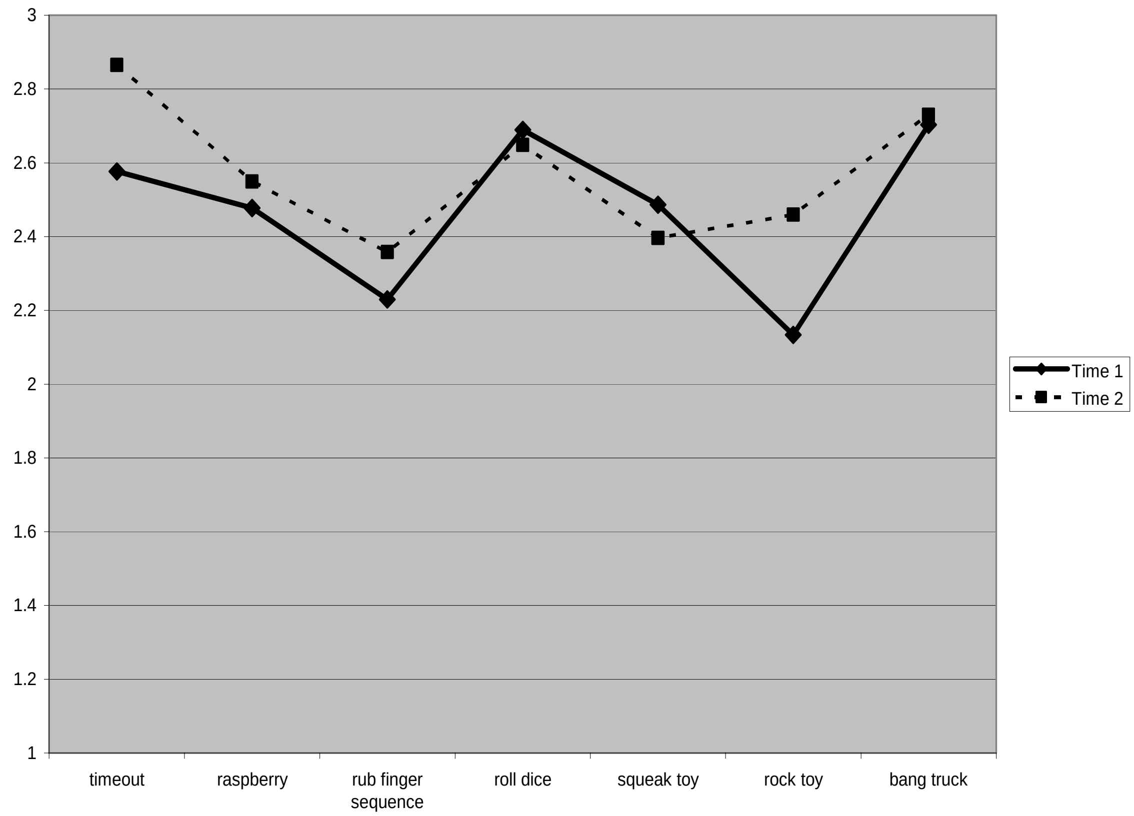


Figure 10. Expected toy manipulation within subjects interaction for task X age X diagnosis

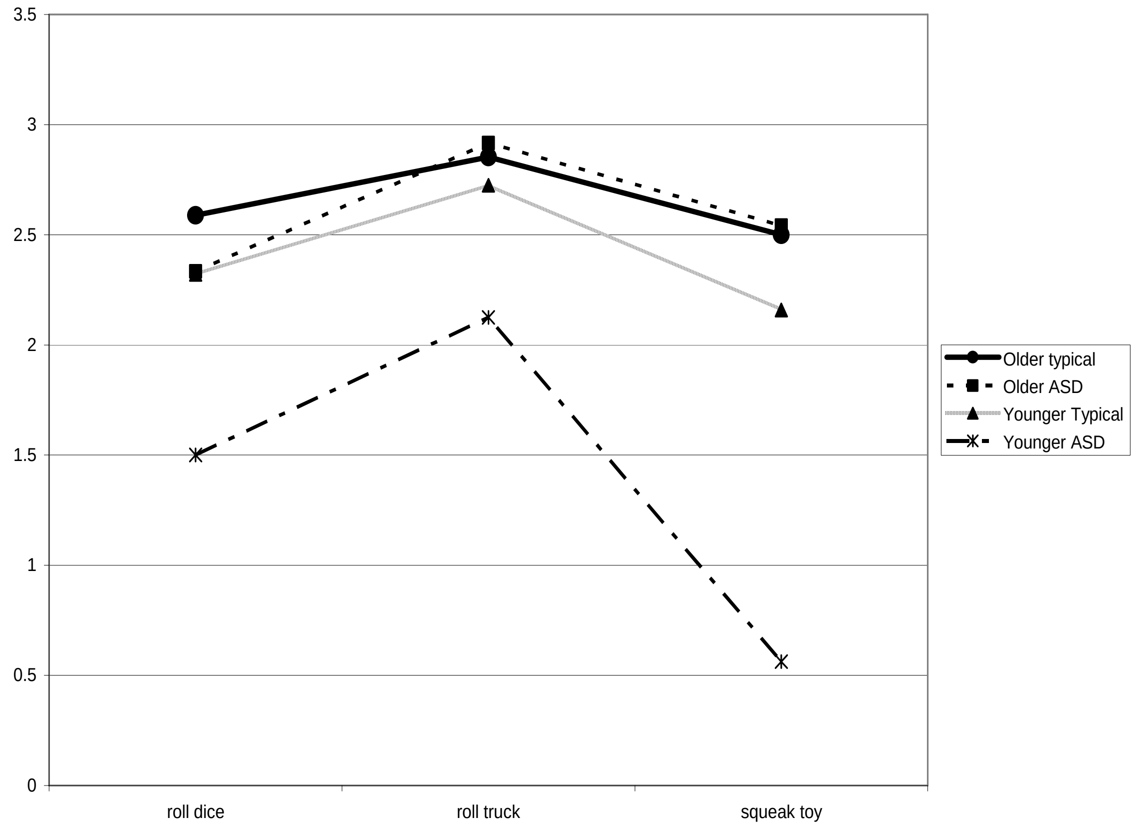


Figure 11. Unexpected toy manipulation with subjects main effect for task

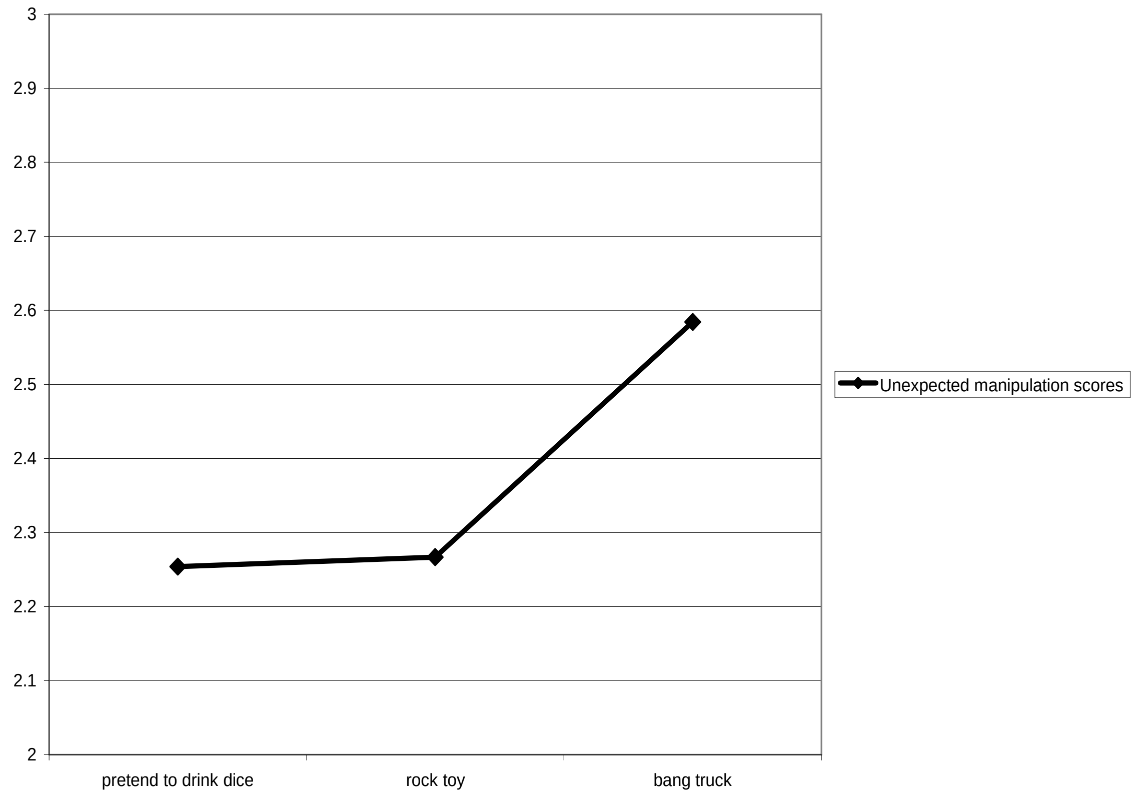


Figure 12. Symbolic task within subjects main effect for task

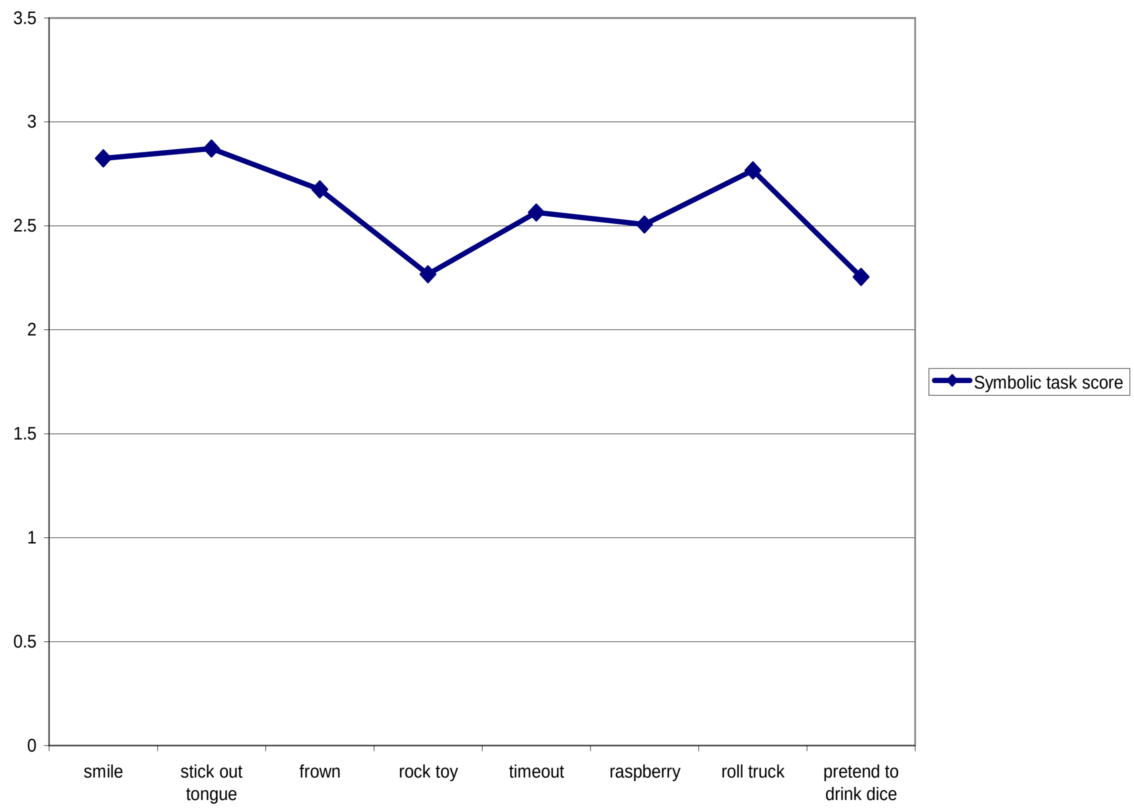


Figure 13. Non symbolic task within subjects interactions (task X age & task X diagnosis)

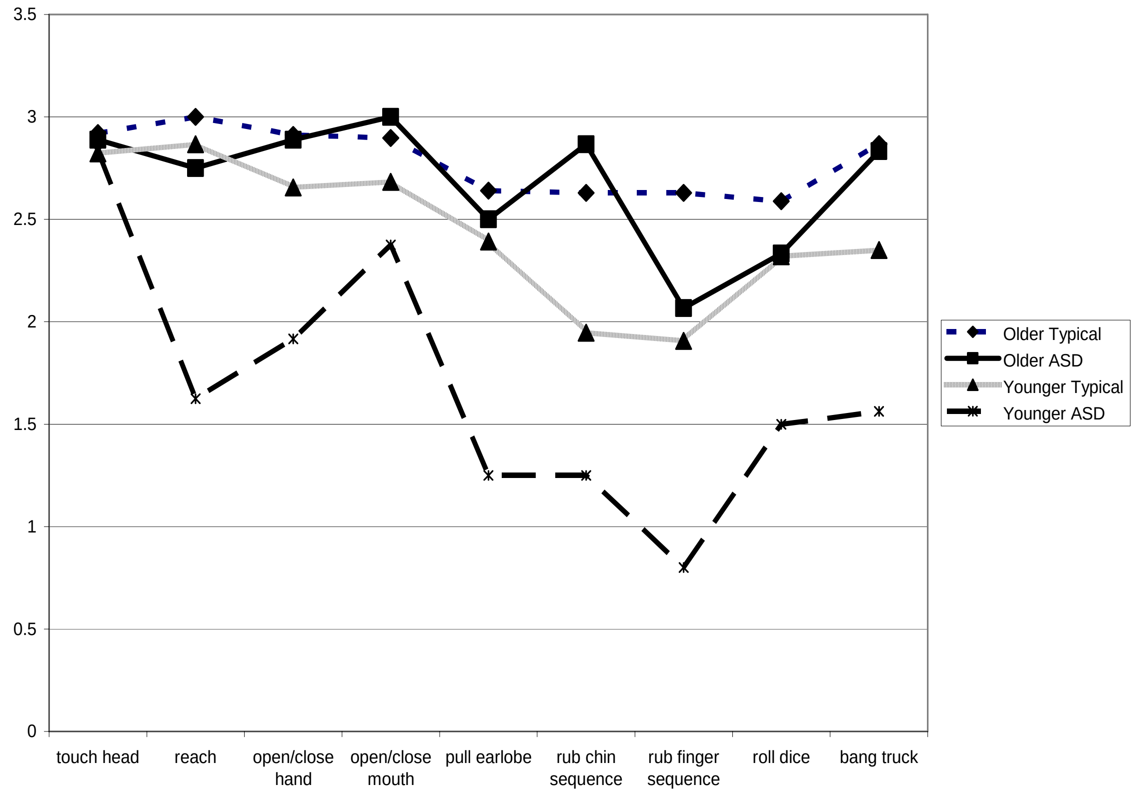


Figure 14. Imitation for all behavior categories – Interaction for task X age X diagnosis

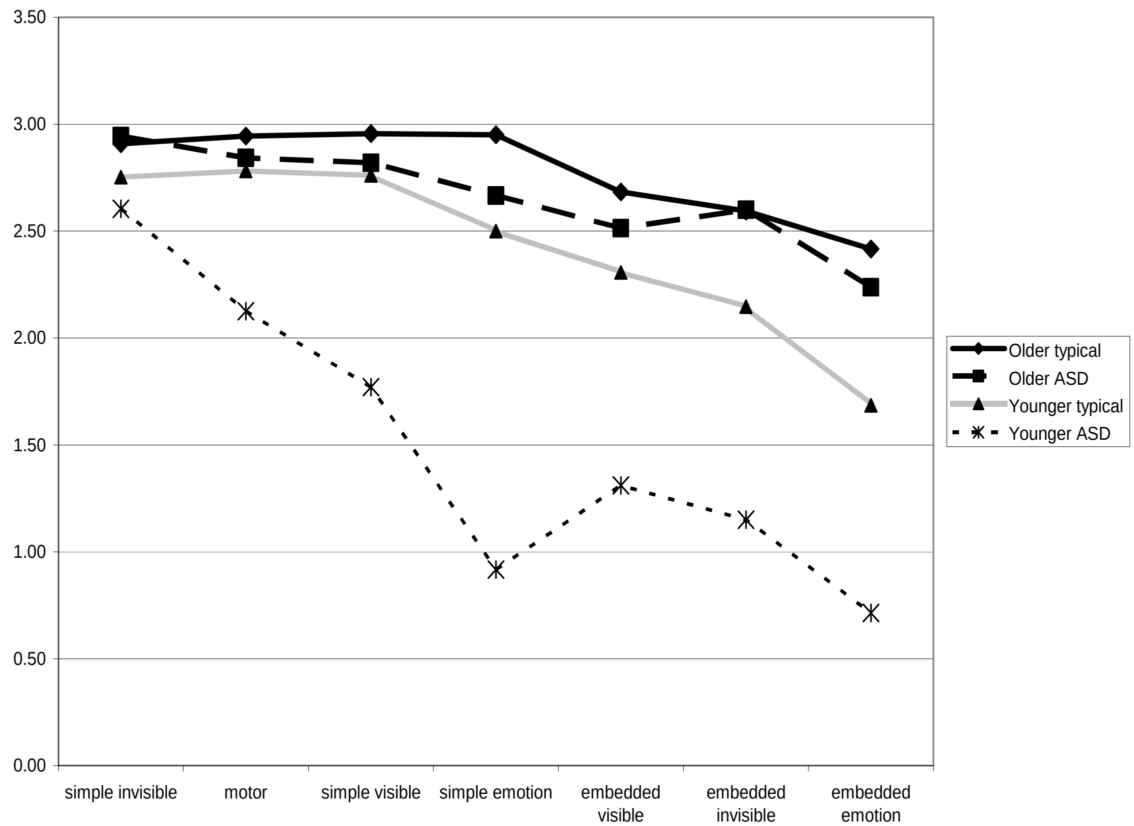
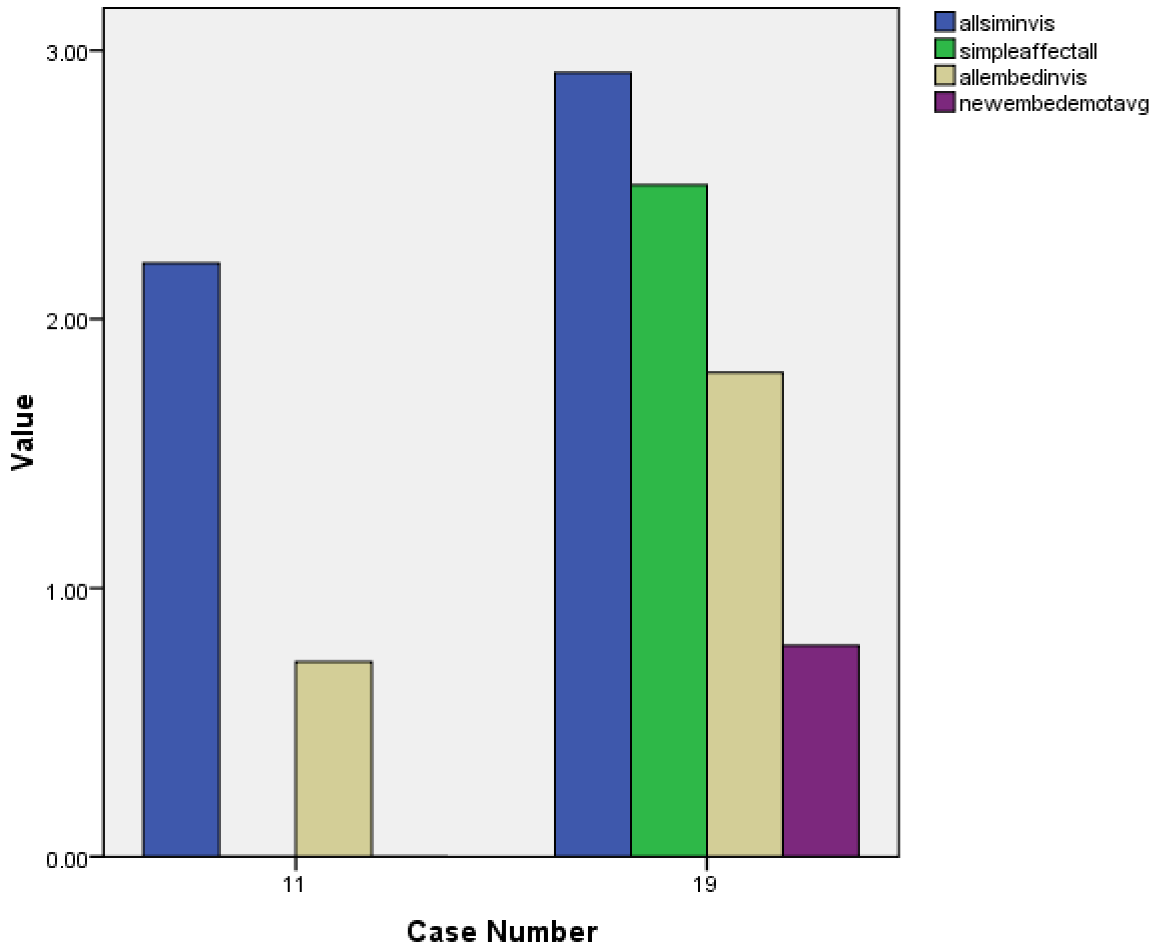
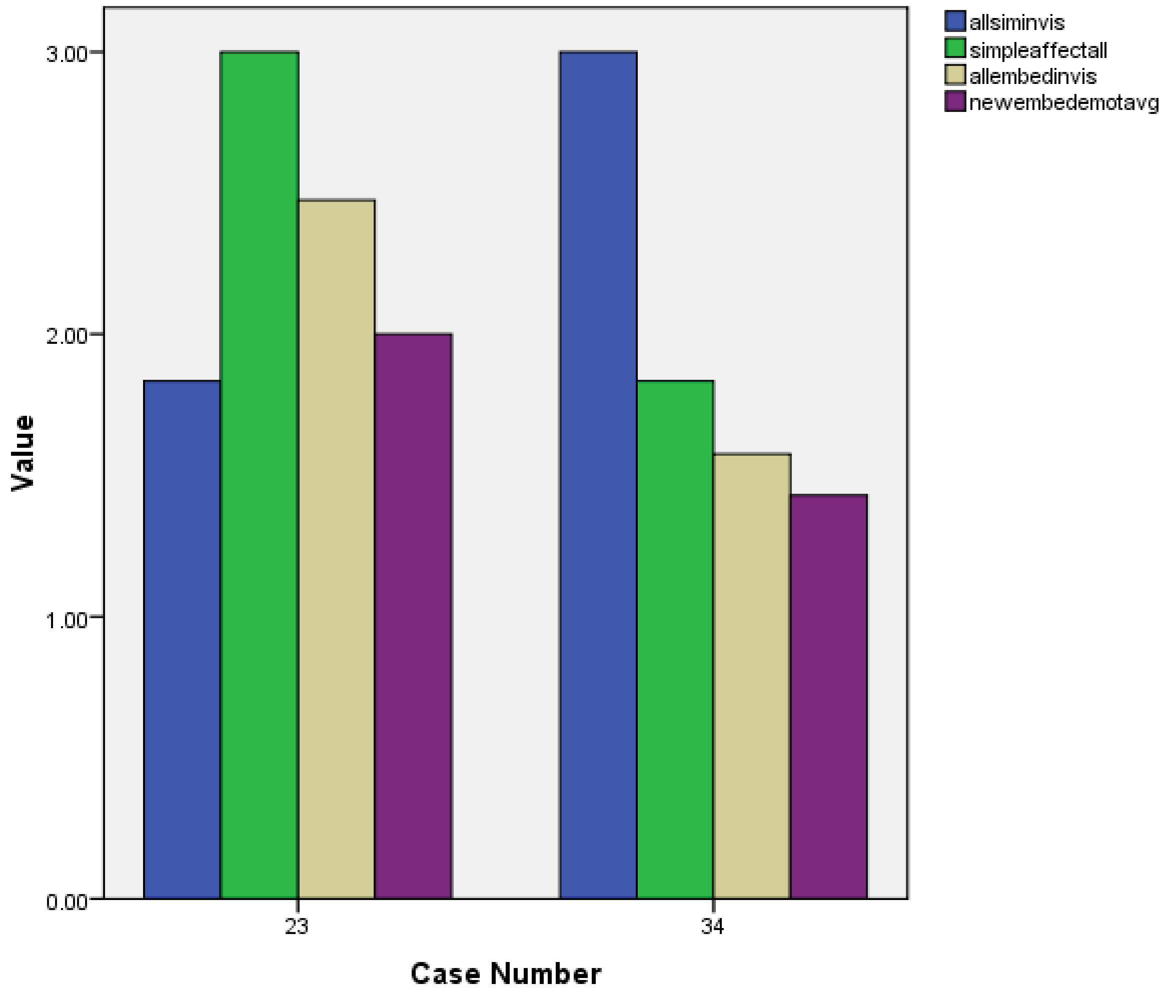


Figure 15. Imitation performance of matched pair subject 11 and subject 19



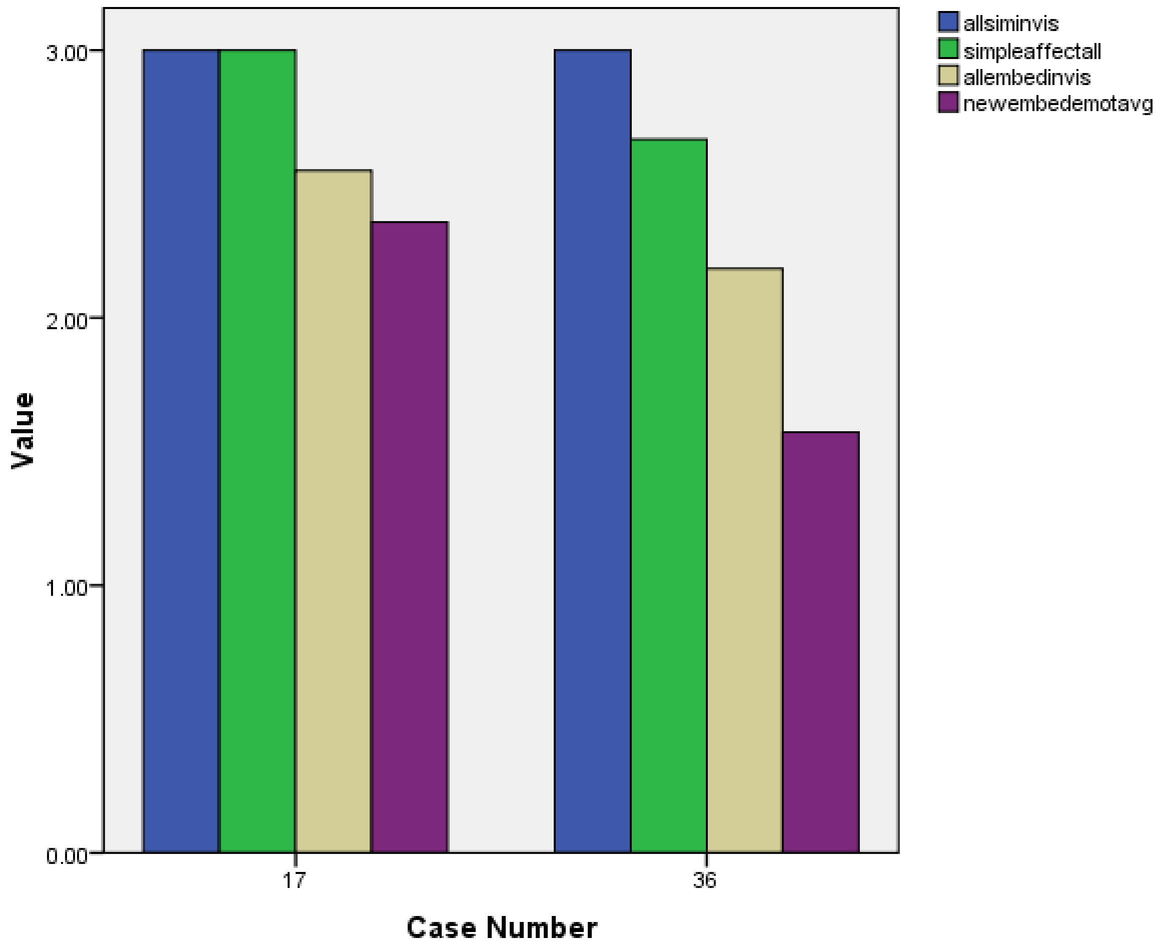
Subject 11 has ASD, is 36 months old.
Subject 19 is typically developing, is 41 months old.

Figure 16. Imitation performance of matched pair subject 23 and subject 34



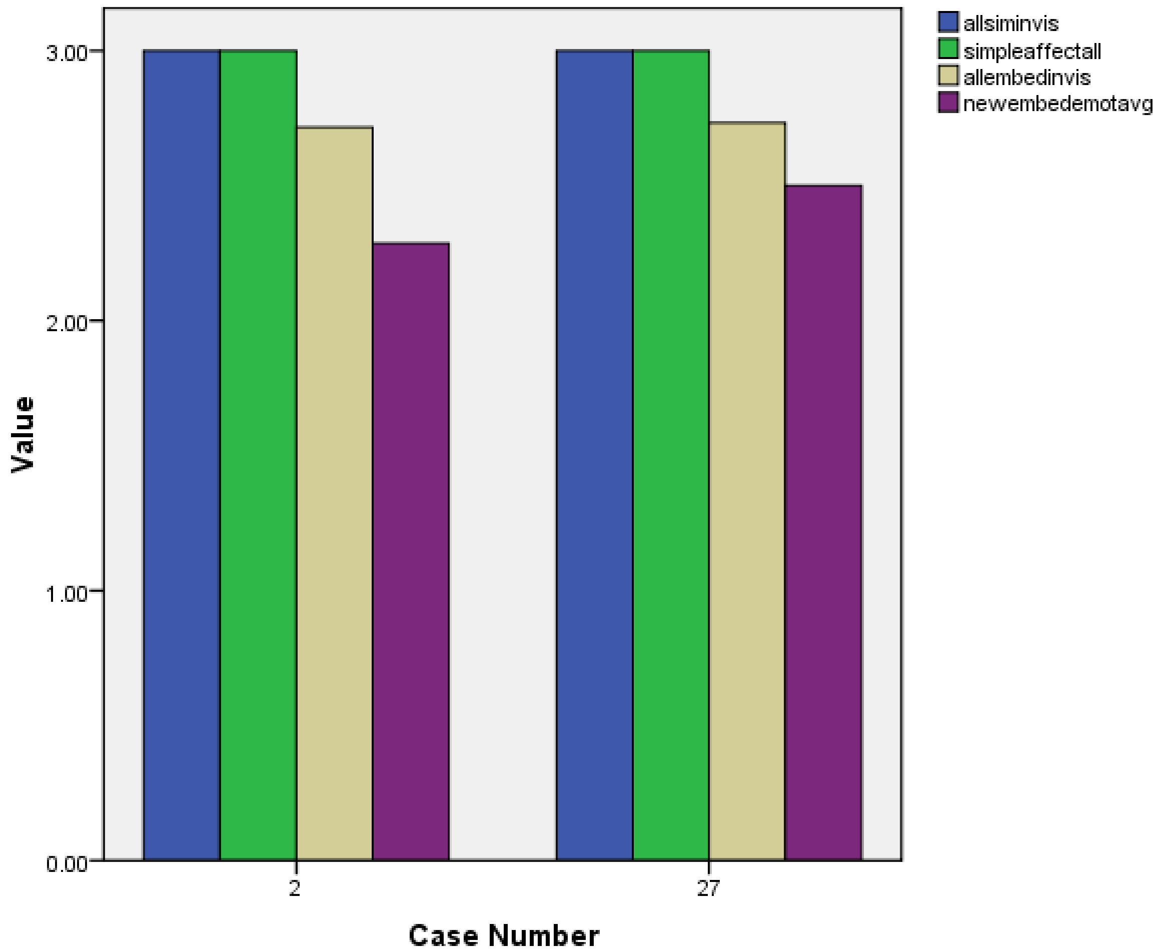
Subject 34 has ADS, is 47 months old.
Subject 23 is typically developing, is 48 months old.

Figure 17. Imitation performance of matched pair subject 17 and subject 36



Subject 17 has ASD, is 54 months old.
Subject 36 is typically developing, is 53 months old.

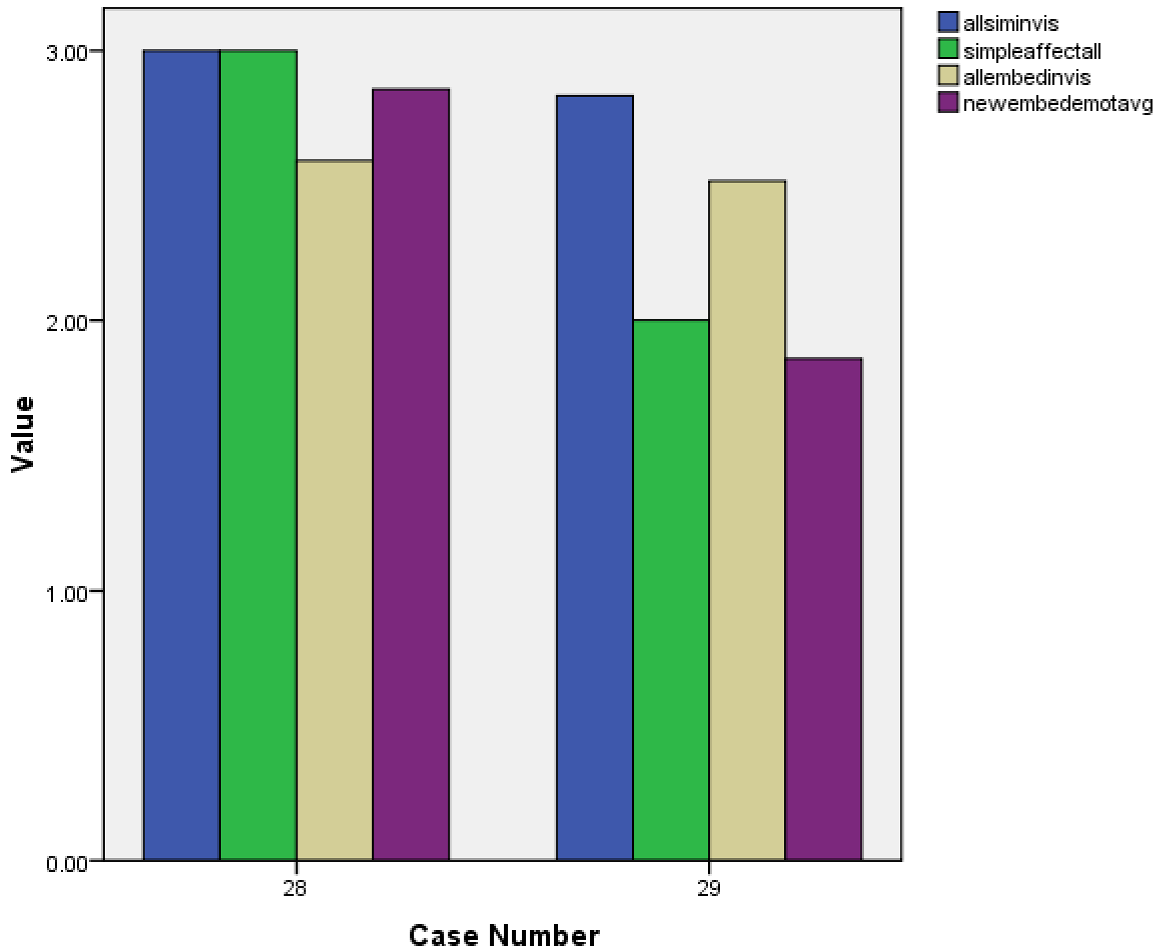
Figure 18. Imitation performance for matched pair subject 2 and subject 27



Subject 27 has ASD, is 58 months old.

Subject 2 is typically developing, is 60 months old.

Figure 19. Imitation performance for matched pair subject 28 and subject 29



Subject 29 has ASD, is 62 months old.
Subject 28 is typically developing, is 58 months old.

Figure 20. Imitation task X age X odor interaction

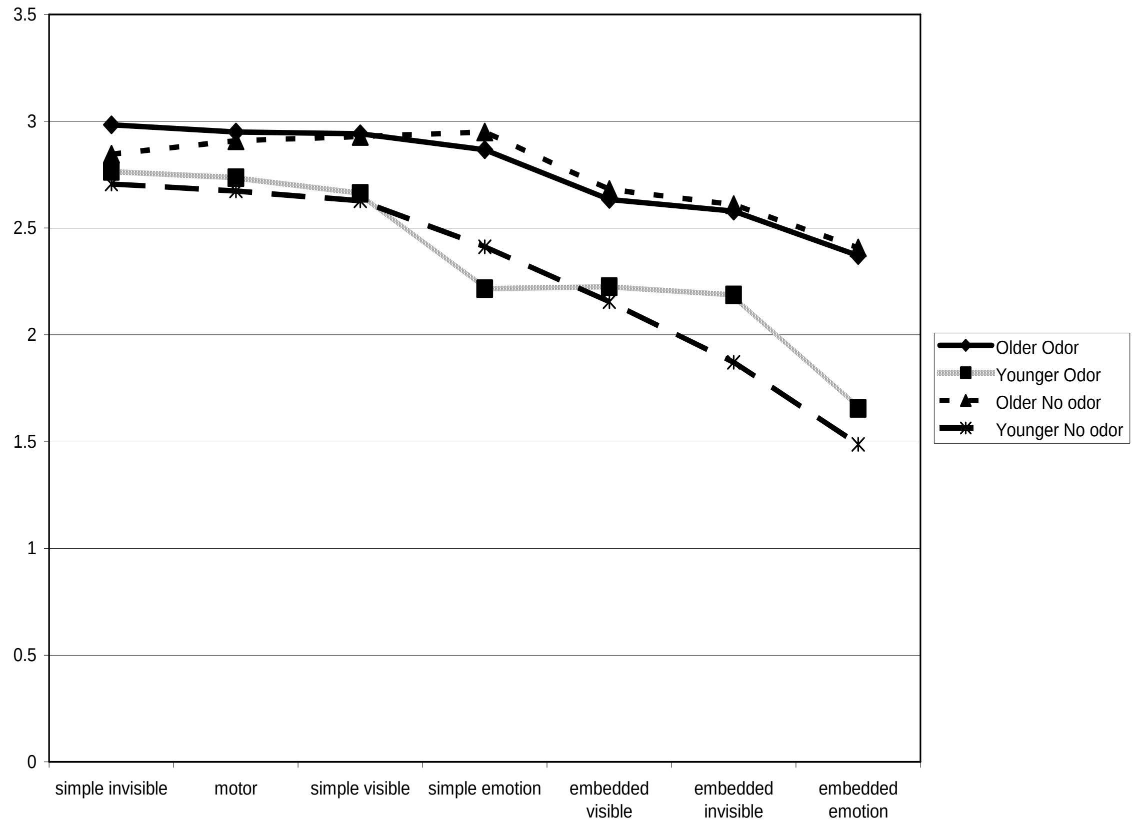
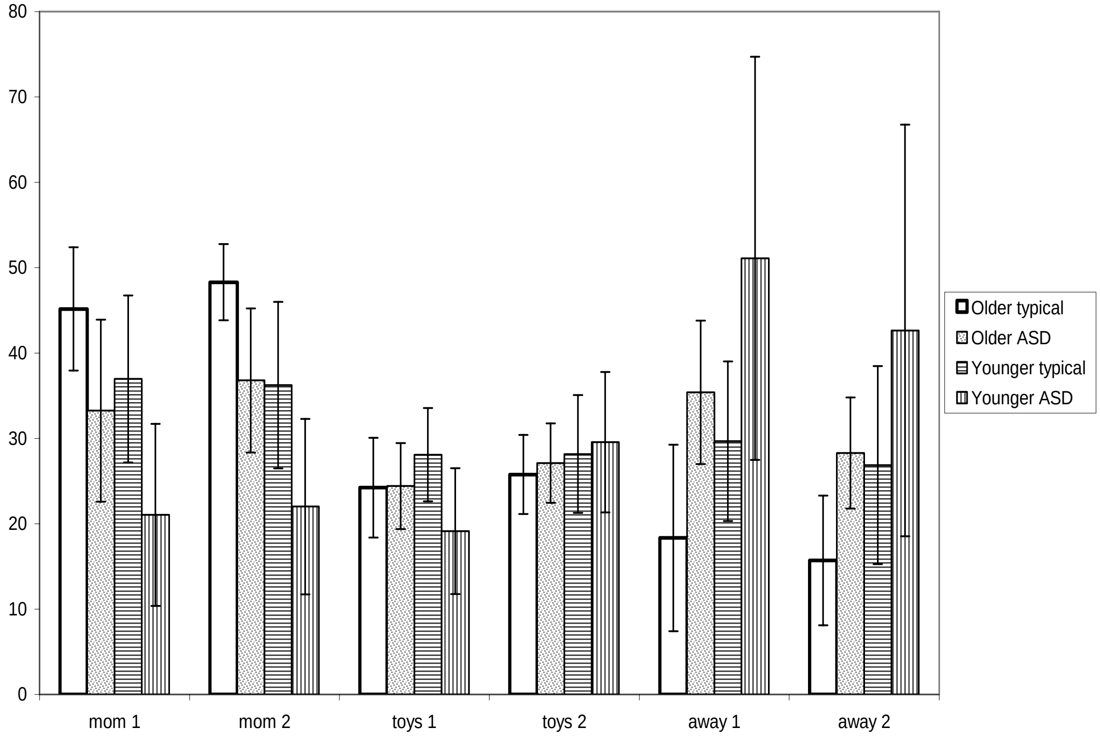


Figure 21. Percent of time spent looking at time 1 and time 2 for age X diagnosis (+/- SD)



Appendix 1. Recruiting materials

INFORMED CONSENT
IMITATION IN THE PRESENCE OF ODOR

I, ________________________________ agree that my child and I will participate in a research study involving 60 preschool age children. The purpose of this study is to investigate the effects of certain environmental stimuli on imitation and social referencing in children. Our participation will facilitate a better understanding of the influence of the environment on human behavior. I understand that we will be exposed to a specially designed light and a barely detectable odor and that there is no known risk of harm from any of these conditions. Very occasionally, some minor sensitivities occur in some people. Further, our participation will involve my modeling 18 gestures for my child for him/her to imitate and then watching an experimenter model 6 more gestures with my child. In addition, my child will complete a 10 minute vocabulary task that will be used for comparison purposes only. The total time of our participation is about 1 hour each session with a total of 2 sessions.

I understand that our participation is confidential. Confidential means that the research records will include some information about us, such as me age, educational background, ethnicity, etc. This information will be kept confidential by limiting individual's access to the research data and keeping it in a secure location. The research team and the Institutional Review Board at Rutgers University are the only parties that will be allowed to see the data, except as may be required by law. If a report of this study is published, or the results are presented at a professional conference, only group results will be stated. All study data will be kept for at least three years.

I UNDERSTAND THAT PARTICIPATION IN THIS EXPERIMENT IS COMPLETELY VOLUNTARY AND THAT I MAY WITHDRAW AT ANY TIME WITHOUT PENALTY. The benefits of taking part in this study may be learning about a potentially effective intervention that will enhance social abilities in preschool age children. However, I may receive no direct benefit from taking part in this study. I understand that I will receive a gift card payment valued at up to $20 for my participation. If I do choose to withdraw, I will receive credit or payment commensurate with the time I have participated. In any event, I will receive a copy of this form for my personal records.

If I have any questions about the study or study procedures, I may
contact Carrie Coffield, email ccoffiel@rci.rutgers.edu, or I may contact her advisor
Dr. Jeannette Haviland Jones, email baljones@rci.rutgers.edu at:
The Human Emotions Laboratory
53 Avenue E – 203 Tillett Hall
Piscataway, NJ 08854
Tel: 732-445-3991.

If you have any questions about your rights as a research subject, you may contact the IRB Administrator at:
Rutgers University, the State University of New Jersey
Institutional Review Board for the Protection of Human Subjects
Office of Research and Sponsored Programs
3 Rutgers Plaza
New Brunswick, NJ 08901-8559
Tel: 732-932-0150 ext. 2104
Email: humansubjects@orsp.rutgers.edu

I agree that my child and I will participate in the study described above.

________________________________ ____________
Signature Date

________________________________ ____________
Investigator Date

VIDEOTAPE ADDENDUM TO CONSENT FORM
IMITATION AND SOCIAL REFERENCING IN THE PRESENCE OF ODOR

You have already agreed to participate in a research study entitled: Imitation and Social Referencing in the Presence of Odor conducted by Carrie Coffield. We are asking for your permission to allow us to videotape (video and audio) as part of that research study. You do not have to agree to be recorded in order to participate in the main part of the study.

The video(s) will be used for analysis by the research team. They will include only the study sessions. Tapes will be labeled with your subject number and will be identified by that code number and not your name. Your child's name will appear on the tape to the extent that you say it during the study.

The video(s) will be stored in a locked filing cabinet in a locked laboratory and linked with a code to subjects' identity. They will be destroyed upon publication of study results.

Your signature on this form grants the investigator named above permission to record you as described above during participation in the above-referenced study. The investigator will not use the video(s) for any other reason than that/those stated in the consent form without your written permission.

____
Parent of Minor Subject (Print)

__________________________________ ______________________
Parent's Signature Date

__________________________________ ______________________
Principal Investigator Signature Date

Dear Parent,

Wouldn’t it be exciting to be able to learn more about imitation and autism while interacting with your child in a fun research environment? You and your child are invited to participate in a study that will test imitation abilities in preschool age children with autism and in typically developing children of the same age. The purpose of this study is to determine if children with autism have a systematic impairment in their ability to imitate and, if they do, what category(s) of behavior seems to be most challenging for them to imitate. In other words, this study will look at what kinds of behavior are most difficult for children with autism to imitate. This study will also try to determine if there is a way to enhance imitation ability in children by providing a more supportive “tent” environment and by adding a pleasant odor. We know from past research that the presence of pleasant odors increases attention and helps regulate mood, even in 6 month old infants. The imitation tasks will be observed in an enhanced “tent” environment that I will bring to your home. To enhance the “tent” environment, we will use a peri-threshold (barely noticeable) level of a pleasant odor. By adding the odor to the environment and using our tent as the study location, we hope to reduce distraction and create a more supportive environment that may enhance attention and social interaction in this scenario.

This study will entail making 2 appointments, spaced 1 week apart, for an experimenter to visit your home at a day and time that is convenient for you. Alternately, we can arrange for you to participate at your child’s school if you pick your child up at the end of the school day. During the study, you will be asked to join your child inside a tent. You will be given a series of cards demonstrating facial expressions and gestures to model for your child. We will also be videotaping the session to code for timing. The entire study is expected to last less than 1 hour during each of the 2 visits. As a thank-you for your participation, you will earn a $20 gift card to Target and your child will earn an Expert Tent Dweller certificate with his/her picture on it.

If you would like to take part in this study, please fill out the contact sheet and review the enclosed consent form. On the contact sheet, provide the best way to get in touch with you to schedule an appointment and please indicate the best days and times to reach you. Please sign the consent form and return it in the envelope provided along with the contact sheet.

Thank you in advance for your help.

Sincerely,

Caroline Coffield

CONTACT SHEET

NAME ____

PHONE NUMBER ____

ADDRESS ____

____

____

Please indicate on the chart below which are the most convenient times for us to contact you. Place the numbers 1, 2, 3 in the boxes below to indicate the #1 best time to contact you, the #2 best time to contact you and the #3 best time to contact you. We will make every attempt to contact you during your preferred times.

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY (indicate time)
NOON – 2						
3PM-5PM						
5PM-7PM						
7PM-9PM						

If you feel you need to contact us, please call:

The Human Emotion Lab
34 Avenue E – Tillett Hall
Rutgers, The State University of NJ
Piscataway, NJ
Jeannette Haviland-Jones, P.hD., Director
732-445-3991

Appendix 2. Coding sheets

Subject # ___________   Visit # _____ Experimenter ___________

	Head/ Eye Orient (2 count)	**Imitates immediately**
Smile1		
Smile2		
Smile3		

	Head/ Eye Orient (2 count)	**Imitates immediately**
Tongue1		
Tongue2		
Tongue3		

	Head/ Eye Orient (2 count)	**Imitates immediately**
Frown 1		
Frown 2		
Frown 3		

Subject # __________ Visit # _____ Experimenter _______________

	Head/ Eye Orient (2 count)	**Arms Out**	**2 hands T**	**O face Yes or No**
Time out with O face 1				
Tim out with O face 2				
Time out with O face 3				

	Head/ Eye Orient (2 count)	**Hands up**	**Palms flat/out**	**Raspberry Yes or No**
Hands up, palms out, raspberry 1				
Hands up, palms out, raspberry 2				
Hands up, palms out, raspberry 3				

	Head/ Eye Orient (2 count)	**$ sign 1**	**Clap**	**$ sign 2**	**Smile Yes or No**
$ sign, clap, $ sign 1					
$ sign, clap, $ sign 2					
$ sign, clap, $ sign 3					

Subject # __________ Visit # _____ Experimenter _______________

	Head/ Eye Orient (2 count)	**Arm Up**	**Pull Ear**	**Gasp Yes or No**
Ear lobe with gasp 1				
Ear lobe with gasp 2				
Ear lobe with gasp 3				

	Head/ Eye Orient (2 count)	**Imitates immediately**
Open close mouth 1		
Open close mouth 2		
Open close mouth 3		

	Head/ Eye Orient (2 count)	**Chin 1**	**Head**	**Chin 2**	**Smile Yes or No**
Scratch chin, head, chin 1					
Scratch chin, head, chin 2					
Scratch chin, head, chin 3					

Subject # __________ Visit # _____ Experimenter_____________

	Head/ Eye Orient (2 count)	Arm Up	Touch Head
Touch head 1			
Touch head 2			
Touch head 3			

	Head/ Eye Orient (2 count)	Imitates immediately
Reach 1		
Reach 2		
Reach 3		

	Head/ Eye Orient (2 count)	Arm Out	Open/Close hand
Open/ close hand 1			
Open/ Close hand 2			
Open/ Close Hand 3			

Subject # __________ Visit # _______ Experimenter _______________

	Head/ Eye Orient (2 count)	Dice in cup	Shake	Roll	Ooo face Yes or No
Yatzee correct 1					
Yatzee correct 2					
Yatzee correct 3					

	Head/ Eye Orient (2 count)	Hold Truck	Roll truck	Vroom Yes or No
Truck with vroom 1				
Truck with vroom 2				
Truck with vroom 3				

	Head/ Eye Orient (2 count)	Hold toy up	Squeak	Haha Yes or No
Squeak toy with haha 1				
Squeak toy with haha 2				
Squeak toy with haha 3				

Subject # __________ **Visit # ______** **Experimenter _______________**

	Head/ Eye Orient (2 count)	Dice in cup	Shake cup	Drink	Ooo face Yes or No
Yatzee then drink 1					
Yatzee then drink 2					
Yatzee then drink 3					

	Head/ Eye Orient (2 count)	Hold baby	Rock baby	Coo Yes or No
Rock toy with coo 1				
Rock toy with coo 2				
Rock toy with coo 3				

	Head/ Eye Orient (2 count)	Hold truck	Bang truck	Growl Yes or No
Bang truck with growl 1				
Bang truck with growl 2				
Bang truck with growl 3				

References

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington DC: Author.

Ashby, F.G., Isen, A.M., & Turken, A.U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review*, 106(3), 529-550.

Autism and Developmental Disabilities Monitoring Network Surveillance. (2009). Prevalence of autism spectrum disorders. (Surveillance Summaries 58(SS10);1-20). Washington, DC: U.S. Government Printing Office.

Baron-Cohen, S. (1989). The autistic child's theory of mind: A case of specific developmental delay. *Journal of Child Psychology and Psychiatry*, 30, 285-297.

Baron-Cohen, S., Leslie, A.M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition*, 21, 37-46.

Baron-Cohen, S., Leslie, A.M., & Frith, U. (1986). Mechanical, behavioral, and intentional understanding of picture stories in autistic children. *British Journal of Developmental Psychology*, 4, 113-125.

Baron-Cohen, S., Ring, H.A., Wheelwright, S., Bullmore, E.T., Brammer, M.J., Simmons,
A., et al. (1999). Social intelligence in the normal and autistic brain: An fMRI s tudy. *The European Journal of Neuroscience,* 11, 1891-1898.

Beadle-Brown, J. (2004). Elicited imitation in children and adults with autism: The effect of different types of actions. *Journal of Applied Research in Intellectual Disabilities*, 17(1), 37-48.

Beadle-Brown, J.D., & Whiten, A. (2004). Elicited imitation in children and adults with autism: Is there a deficit? *Journal of Intellectual and Developmental Disability*, 29(2), 147-163.

Begeer, S., Rieffe, C., Terwogt, M.M. & Stockman, L. (2006). Attention to facial emotional expressions in children with autism. *Autism*, 10(1), 37-51.

Berger, M. (2006). A model of preverbal social development and its application to social dysfunctions in autism. *Journal of Child Psychology and Psychiatry, 47*(3/4), 338-371.

Boraston, Z., Blakemore, S.J., Chilvers, R., & Skuse, D. (2007). Impaired sadness recognition is linked to social interaction deficit in autism. *Neuropsychologist*, 45, 1501-1510.

Braverman, M., Fein, D., Lucci, D., & Waterhouse, L. (1989). Affect comprehension in children with pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, 19, 301-316.

Buck, L., & Axel, R. (1991). A novel multigene family may encode odorant receptors: a molecular basis for odor recognition. *Cell*, 65, 175 – 187.

Buitelaar, J.K., van der Wees, M., Swaab-Barneveld, H., & van der Gaag, R.J. (1999). Verbal memory and performance IQ predict theory of mind and emotion recognition ability in children with autism spectrum disorder and in psychiatric control children. *Journal of Child Psychology and Psychiatry*, 40(6), 869-881.

Butterworth, G. (1999). Neonatal imitation: Existence, mechanisms and motives. In J. Nadal, & G. Butterworth (Eds.), *Imitation in Infancy* (pp.. 63 – 88). New York: Cambridge University Press.

Caron, A.J., Caron, R.F., & MacLean, D.J. (1988). Infant discrimination of naturalistic emotional expressions: The role of face and voice. *Child Development*, 59, 604-616.

Carpenter, M., Pennington, B. F., & Rogers, S.J. (2001). Understanding of others' intentions in children with autism. *Journal of Autism and Developmental Disorders,* 31(6), 589-599.

Charman, T., & Baron-Cohen, S. (1994). Another look at imitation in autism. *Development and Psychopathology*, 6, 403-413.

Cicchetti, D., & Beeghly, M. (1990). An organizational approach to the study of Down syndrome: Contributions to an integrative theory of development. In D. Cicchetti & M. Beeghly (Eds.), *Children with Down Syndrome: A Developmental Perspective* (pp. 29-62). New York: Cambridge University Press.

Curcio, F. (1978). Sensorimotor functioning and communication in mute autistic children.
Journal of Autism and Childhood Schizophrenia, 8(3), 281-292.

Dapretto, M., Davies, M.S., Pfeifer, J.H., Scott, A.A., Sigman, M., et al. (2006). Understanding emotions in others: Mirror neuron dysfunction in children with autism spectrum disorders. *Nature Neuroscience*, 9, 28-30.

Dawson, G., & Lewy, A. (1989). Arousal, attention, and the socioemotional impairments of individuals with autism. In G. Dawson (Ed.), *Autism: Nature, diagnosis, and treatment* (pp. 49-74). New York: Guilford Press.

Degel, J., & Koster, E.P. (1999). Odors: Implicit memory and performance effects. *Chemical Senses*, 24: 317-325.

DeMyer, M.K., Alpern, G.D., Barton, S., DeMyer, W.E., Churchill, D.W., Hingtgen, J.N., Bryson, C.Q., Pontius, W., & Kimberlin, C. (1972). Imitation in autistic, early schizophrenic, and non-psychotic subnormal children. *Journal of Autism and Childhood Schizophrenia*, 2(3), 264-287.

Devouche, E. (2004). Mother versus stranger: A triadic situation of imitation at the end of the first year of life. *Infant and Child Development*, 13(1), 35-48.

Dunn, L.M. & Dunn, L.M. (1997). Peabody Picture Vocabulary Test – Third Edition. American Guidance Services.

Ehrlichman, H., Kuhl, S.B., Zhu, J., & Warrenburg, S. (1997). Startle reflex modulation by pleasant and unpleasant odors in a between-subjects design. *Pyschophysiology*, 34(6), 726-729.

Epple, G., & Herz, R.S. (1999). Ambient odors associated to failure influence cognitive performance in children. *Developmental Psychobiology*, 35(2), 103-107.

Fiske, G.M. (2008). *Exploring Motivat.ion for Social Interaction in Children with Autism.*
Unpublished doctoral dissertation, Northwestern University, Evanston.

Fogassi, L., Ferrari, P.F., Gesierich, B., Rozzi, S., Chersi, F., & Rizzolatti, G. (2005). Parietal lobe: From action organization to intention understanding. *Science*, 308, 662-667.

Fredrickson, B.L. & Levenson, R.W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition and Emotion*, 12(2), 191-220.

Gallese, V., & Goldman, A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends in Cognitive Sciences,* 2, 493-501.

Goubet, N., Rattaz, C., Pierrat, V., Bullinger, A., & Lequien, P. (2003). Olfactory experience mediates response to pain in preterm newborns. *Developmental Psychobiolgoy*, 42, 171 – 180.

Graziano, A. M. (2002). Autistic Spectrum Disorders. In *Developmental Disabilities: Introduction to a Diverse Field*. Boston: Allyn & Bacon.

Grelotti, D. J., Gauthier, I., & Schultz, R. T. (2002). Social interest and the development of cortical face specialization: What autism teaches us about face processing. *Developmental Psychobiology*, 40(3), 213-225.

Gross, E.R. (1994). Nonaversive olfactory conditioning to control aggressive behaviors of a blind, hearing impaired, and noncommunicating child. *Journal of Developmental and Physical Disabilities*, 6(1), 77-82.

Hamilton, A.F.D., Brindley, R.M., & Frith, U. (2007). Imitation and action understanding in autistic spectrum disorders: How valid is the hypothesis of a deficit in the mirror neuron system? *Neuropsychologia*, 45, 1859-1868.

Hertzig, M.E., Snow, M.E., & Sherman, M. (1989). Affect and cognition in autism. *Journal of the American Academy of Child and Adolescent Psychiatry,* 28, 195-199.

Hobson, R.P. (1986). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry,* 27(3), 321-342.

Hobson, J.A., & Hobson, R.P. (2007). Identification: The missing link between joint attention and autism? *Development and Psychopathology*, 19, 411-431.

Hobson, R.P., & Hobson, J.A. (2008). Dissociable aspects of imitation: A study in autism. *Journal of Experimental Child Psychology*, 101, 170-185.

Hobson, R.P., & Lee, A. (1999). Imitation and identification in autism. *Journal of Child Psychology and Psychiatry*, 40(4), 649-659.

Hobson, R.P., & Meyer, J.A. (2005). Foundations for self and other: A study in autism. *Developmental Science*, 8, 481-491.

Hobson, P., & Meyer, J. (2006). Imitation, identification, and the shaping of mind: Insights from autism. In S.J. Rogers & J.H.G. Williams (Eds.), *Imitation and the Social Mind: Autism and typical development* (pp. 198 - 226). New York: The Guildford Press.

Hobson, R.P., Outston, J., & Lee, A. (1989). Naming emotion in faces and voices: Abilities and disabilities in autism and mental retardation. *British Journal of Developmental Psychology*, 7, 237-250.

Holland, R.W., Hendriks, M., & Aarts, H. (2005). Smells like clean spirit: Nonconscious effects of scent on cognition and behavior. *Psychological Science*, 16(9), 689-693.

Holmes, A. M. (2002). Theory of mind and behaviour disorders in children with specific language impairment. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 62*(11-B), pp.

Hughes, C., & Ensor, R. (2005). Executive function and theory of mind in 2 year olds: A family affair? *Developmental Neuropsychology,* 28(2), 645-668.

Ingersoll, B. (2008). The social role of imitation in autism: Implications for the treatment of imitation deficitis. *Infants and Young Children*, 21(2), 107-119.

Ingersoll, B. (2008a). The effect of context on imitation skills in children with autism. *Research in Autism Spectrum Disorders*, 2, 332-340.

Ingersoll, B., Schreibman, L., & Tran, Q.H. (2003). Effect of sensory feedback on immediate object imitation in children with autism. *Journal of Autism and Developmental Disorders*, 33(6), 673-683.

Kasari, C., Mundy, P., Yirmiya, N., & Sigman, M. (1990). Affect and attention in children with Down syndrome. *American Journal on Mental Retardation*, 95(1), 55-67.

Klin, A., Volkmar, F.R., & Sparrow, S. S. (1992). Autistic Social Dysfunction: Some limitations of the Theory of Mind hypothesis. *Journal of Child Psychology and Psychiatry*, 33(5), 861-876.

Langdell, T. (1978). Recognition of faces: An approach to the study of autism. *Journal of Child Psychology and Psychiatry*, 19, 255-268.

Leslie, A.M. (1987). Pretense and representation: Origins of “Theory of Mind”. *Psychological Review*, 94(4), 412-426.

Leslie, A.M., & Frith, U. (1988). Autistic children’s understanding of seeing, knowing, and believing. *British Journal of Developmental Psychology*, 6, 315-324.

Loveland, K.A., Tunali-Kotoski, B., Pearson, D.A., Brelsford, K.A., Ortegon, J. & Chen, R. (1994). Imitation and expression of facial affect in autism. *Development and Psychopathology*, 6, 433-444.

McDuffie, A., Turner, L., Stone, W., Yoder, P., Wolery, M., & Ulman, T. (2007). Developmental correlates of different types of motor imitation in young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders,* 37, 401-412.

Masur, E.F. (2006). Vocal and action imitation by infants and toddlers during dyadic interactions: Development, causes and consequences. In S.J. Rogers & J.H.G. Williams (Eds.), *Imitation and the Social Mind: Autism and typical development* (pp. 27-47). New York: The Guildford Press.

Meltzoff, A.N. (1988). Infant imitation and memory: Nine-month olds in immediate and deferred tests. *Child Development*, 59, 217-225.

Metlzoff, A., & Gopnik, A. (1993). The role of imitation in understanding persons and developing a theory of mind. In S. Baron-Cohen, H. Tager-Flusberg, & D.J. Cohen (Eds.), *Understanding Other Minds: Perspectives from Autism* (pp.335 – 366). Oxford: Oxford University Press.

Meltzoff, A.N., & Moore, M.K. (1977). Imitation of facial and manual gestures by human neonates, *Science*, 198, 75-78.

Meltzoff, A.N., & Moore, M.K. (1999). Person and representation: Why infant imitation is important for theories of development. In J. Nadal, & G. Butterworth (Eds.), *Imitation in Infancy* (pp. 9-35). New York: Cambridge University Press.

Morgan, S.B., Cutrer, P.S., Coplin, J.W., & Rodrigue, J.R. (1989). Do autistic children differ from retarded and normal children in Piagetian sensorimotor functioning? *Journal of Child Psychology and Psychiatry*, 30(6), 857-864.

Nishitani, N., & Hari, R. (2002). Viewing lip forms: Cortical dynamics. *Neuron*, 36, 1211-1220.

Oberman, L.M., & Ramachandran, V.S. (2007). The simulation social mind: The role of the mirror neuron system and simulation in the social and communicative deficits of autism spectrum disorder. *Psychological Bulletin*, 133(2), 310-327.

Ozonoff, S., & Miller, J.N. (1995). Teaching theory of mind: A new approach to social skills training for individuals with autism. *Journal of Autism and Developmental Disorders*, 25(4), 415-433.

The Pacific Gas and Electric Company. (1999, August). Daylighting in schools: An investigation into the relationship between daylighting and human performance. Fair Oaks, CA: Author.

Perra, O., Williams, J.H.G., Whiten, A., Fraser, L., Benzie, H., & Perrett, D.I. (2008). Imitation and 'theory of mind' competencies in discrimination of autism from other neurodevelopmental disorders. *Research in Autism Spectrum Disorders*, 2, 456-468.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience*, 27, 169-192.

Rogers, S.J. (1996). Brief report: Early intervention in autism. *Journal of Autism and Developmental Disorders*, 26(2), 243-246.

Rogers, S.J. (2006). Preface. In S.J. Rogers, & J.H.G. Williams (Eds.), *Imitation and the Social Mind* (pp. ix - xii). New York: The Guilford Press.

Rogers, S.J., Bennetto, L., McEvoy, R., & Pennington, B.F. (1996). Imitation and pantomime in high functioning adolescents with autism spectrum disorders. *Child Development*, 67, 2060-2073.

Rogers, S.J., Hepburn, S.L., Stackhouse, T., & Wehner, E. (2003). Imitation performance in toddlers with autism and those with other developmental disorders. *Journal of Child Psychology and Psychiatry*, 44(5), 763-781.

Rogers, S.J., & Pennington, B.F. (1991). A theoretical approach to the deficits in infantile autism. *Development and Psychopathology*, 3, 137-162.

Schaal, B., Marlier, L., & Soussignan, R. (2000). Human fetuses learn odors from their pregnant mother's diet. *Chemical Senses*, 25, 729-737.

Schultz, R.T. (2005). Developmental deficits in social perception in autism: The role of the amygdala and fusiform face area. *International Journal of Developmental Neuroscience*, 23, 125-141.

Sigman, M. (1989). The application of developmental knowledge to a clinical problem: The study of childhood autism. In D. Cicchetti (Ed.), *The Emergence of a Discipline: Rochester Symposium on Developmental Psychopathology* (pp. 165-187). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Smith, I.M., & Bryson, S.E. (1994). Imitation and action in autism: A critical review. *Psychological Bulletin*, 116(2), 259-273.

Smith, I.M., & Bryson, S.E. (1998). Gesture imitation in autism: Nonsymbolic postures and sequences. *Cognitive Neuropsychology*, 15, 747-770.

Smith, I.M., & Bryson, S.E. (2007). Gesture imitation in autism II. Symbolic gestures and pantomimed object use. *Cognitive Neuropsychology*, 24, 679-700.

Smith, I.M., Lowe-Pearce, C., & Nichols, S.L. (2006). Assessment of imitation abilities in autism: Conceptual and methodological issues. In S.J. Rogers & J.H.G. Williams (Eds.), *Imitation and the Social Mind: Autism and typical development* (pp. 377-398). New York: The Guildford Press.

Stern, D. (1985). *The interpersonal world of the infant.* New York, Basic.

Stone, W.L., Ousley, O.Y., & Littleford, C.D. (1997). Motor imitation in young children with autism: What's the object? *Journal of Abnormal Child Psychology*, 25(6), 475-485.

Theoret, H., Halligan, E., Kobayashi M., Fregni, F., Tager-Flusberg, H., & Pascual-Leone, A. (2005). Impaired motor facilitation during action observation in individuals with autism spectrum disorder. *Current Biology*, 15, R84-R85.

Uzgiris, I. (1999). Imitation as activity: Its developmental aspects. In J. Nadal, & G. Butterworth (Eds.), *Imitation in Infancy* (pp. 186 - 206). New York: Cambridge University Press.

Uzgiris, I.C., & Hunt, J.M. (1975). *Assessment in infancy: Ordinal scales of psychological development.* Urbana: IL: University of Illinois Press.

Vanvuchelen, M., Roeyers, H., & De Weerdt, W. (2007). Nature of motor imitation problems in school-aged boys with autism. *Autism*, 11(3), 225-240.

Volkmar, F., Lord, C., Bailey, A., Schultz, R.T., & Klin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry*, 45(1), 135-170.

Walker-Andrews, A.S. (1997). Infants' perception of expressive behaviors: Differentiation of multimodal information. *Psychological Bulletin,* 121(3), 437-456.

Wetherby, A.M., & Prutting, C.A. (1984). Profiles of communicative and cognitive-social abilities in autistic children. *Journal of Speech and Hearing Research*, 27, 364-377.

Whalen, C. (2001). Joint attention training for children with autism and the collateral effects on language, play, imitation, and social behaviors. *Dissertation Abstracts International*, 61(11), 6122-B. (UMI No. 9995991).

Whiten, A., & Brown, J. (1998) Imitation and the reading of other minds: Perspectives from the study of autism, normal children, and non-human primates. In S. Braten (Ed.), *Intersubjective communication and emotion in early ontogeny* (pp. 260-280). New York: Cambridge University Press.

Williams, J.H.G. (2008). Self-other relations in social development and autism: Multiple roles for mirror neurons and other brain bases. *Autism Research*, 1, 73-90.

Williams, J.H.G., Whiten, A., & Singh, T. (2004). A systematic review of action imitation in autistic spectrum disorder. *Journal of Autism and Developmental Disorders*, 34, 285-299.

Williams, J.H.G., Whiten, A., Suddendorf, T., & Perrett, D.I. (2001). Imitation, mirror neurons and autism. *Neuroscience and Biobehavioral Reviews*, 25, 287-295.

Williams, J.H.G., Whiten, A., Waiter, G.D., Pechey, S., & Perrett, D.I. (2007). Cortical and subcortical mechanisms at the core of imitation. *Social Neuroscience*, 2, 66-78.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and contraining function of wrong beliefs in young children's understanding of deception. *Cognition*, 13, 103-128.

Wing, L. (1988). The continuum of autistic characteristics. In E. Schopler & G. Mesibov (Eds.), *Diagnosis and assessment in autism*. New York: Plenum Press.

Curriculum Vitae

Caroline N. Coffield

2010	Rutgers University, New Brunswick.	PhD. Psychology.
2005	Rutgers University, New Brunswick.	M.S. Psychology.
2003	University of Notre Dame, South Bend,	B.A. Psychology.