

MAKING THE CHOICE: STYLE, PATH, OR GOAL?  
IMITATION IN AUTISM SPECTRUM DISORDERS

by

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## ABSTRACT

Previous research has demonstrated mixed results with regard to the nature of imitation impairments in children with autism spectrum disorders (ASD). While imitation of actions on objects has generally been thought to be less effected, the “style” or way in which an action is performed has been suggested to be impaired in individuals with ASD (Hobson & Hobson, 2008; Hobson & Lee, 1999). This study examined imitation of an action through style, path, and goal components using the imitation choice task developed by Wagner, Yocom, and Greene-Havas (2008). The main questions this study sought to examine were: (1) Do young children with ASD imitate aspects of an imitative action on an object at the same rate as typically developing children?; and (2) When exact imitation is precluded, are there differences in what children with ASD and typical development choose to imitate? The results revealed that children with typical development showed more imitation of the style component than the children with ASD. In the choice imitation condition, children with ASD demonstrated neither a path nor a goal preference while children with typical development showed a path preference. Overall, the results suggest that the components that children with ASD choose to imitate differ from those that children with typical development prefer. These results may help explain some of the discrepant findings previously reported in the imitation literature. Specifically, these results suggest that children with ASD do imitate, but how they imitate is different. This may have important implications for the assessment of imitation abilities and interventions that address imitation or use imitation to teach other skills. This may have

important implications for refining measures to assess imitation abilities in a more detailed manner. Additionally, these results have implications for designing and implementing interventions that address imitation or use imitation to teach other skills as merely teaching imitation of a behavioral goal does not capture the true nature of imitation.

## LIST OF ABBREVIATIONS AND SYMBOLS

$F$	Fisher's $F$ ratio: A ratio of two variances
$M$	Mean: the sum of a set of measurements divided by the number of measurements in the set
$p$	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
$r$	Pearson product-moment correlation
$t$	Computed value of $t$ test
$\eta_p^2$	Partial eta squared
$SD$	Standard deviation
$<$	Less than
$>$	Greater than
$=$	Equal to

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## Introduction

Human beings may be the most social creatures on earth. As social beings, humans are capable of creating and experiencing for ourselves as well as experiencing and learning from the creations of others. Thus, a fundamental part of the human experience is the ability to observe and imitate others. It is so fundamental that it can be difficult to imagine life without this capacity. In typically developing infants, imitation appears to be an innate ability as infants only a few hours old demonstrate basic imitative abilities (Meltzoff & Moore, 1983, 1989). Piaget (1962) stated that “the child learns to imitate, and this learning process, like any other, raises all the problems involved in ... mental development.” Thus, imitation seems to be a fundamental skill necessary for engaging in more complex learning and has been suggested to be a precursor to social-cognitive functioning (Meltzoff & Gopnik, 1993; Rogers & Pennington, 1991). However, for some individuals this capacity does not come as naturally, specifically individuals with autism spectrum disorders (ASD), which is a disorder of social communication.

The ability to observe and copy other people is the primary way in which young children learn language and social interaction (Kuhl, 2007; Meltzoff, 2007; Meltzoff & Prinz, 2002; Nadel & Butterworth, 1999). Imitation serves as the connection between what we observe and what we do. Thus, impairments in imitation likely contribute to the impaired social communication skills that define ASD. These impairments in turn are then likely to have negative cascading effects on a child's life across multiple domains of

development. Given the importance of imitation in social communication development, it is an extremely important ability to examine. However, imitation is easily overlooked as a result of the prominent language, social, and behavioral difficulties that have their basis in imitation abilities that develop out of this foundation. Understanding disruptions in this foundational skill can give insight into how the difficulties seen in individuals with ASD emerge over time. Since the majority of individuals with ASD do develop certain competencies in skills that rely on the use of some level of imitation, we can examine not only weaknesses but also strengths.

#### *Focus on Autism Spectrum Disorders and Imitation*

Autistic disorder, Asperger's disorder, and Pervasive Developmental Disorder-Not Otherwise Specified represent a category of DSM-IV-TR defined pervasive developmental disorders that are characterized by impaired verbal and nonverbal communication, impairments in reciprocal social interaction, and restricted, repetitive, and stereotyped behaviors and interests (American Psychiatric Association [APA], 2000). More recently, the term autism spectrum disorder (ASD) has been proposed for the forthcoming DSM-V to describe this range of cognitive and behavioral symptoms (APA, 2011). Individuals with ASD can vary greatly in terms of their symptomatology and intellectual functioning (ranging from mildly to severely impaired), making this truly a 'spectrum' disorder. Behavioral symptoms are present early in childhood and typically persist across the lifespan, although their presentation typically changes throughout development. Similarly, cognitive symptoms, such as difficulties with joint attention (Mundy & Burnette, 2005), theory of mind (Baron-Cohen, 2000), implicit learning (Klinger, Klinger, & Pohlig, 2006), and central coherence (Happé, 2005), have been

posited across the lifespan although the severity of impairment may change. For example, early hallmark symptoms of ASD, such as the absence of joint attention, may not necessarily persist in later childhood. Due to this changing pattern of symptoms across development, an examination of ‘core’ impairments, specific and unique to ASD, should focus on symptoms present early in development.

This research focuses on one specific early social impairment in ASD, imitation. Previous research, which is discussed in this review, has demonstrated that children with ASD have impaired imitation skills that may play a role in their cognitive and social impairments. Despite these impairments, children with ASD do learn to imitate in some instances. However, little is known about the process by which children with ASD use and learn from imitation. Specifically, most research has investigated the question of “do” children with ASD imitate rather than asking “how” children with ASD imitate. This dissertation study is a more detailed examination of imitation in children with ASD, asking questions about “how” children with ASD imitate.

### *The Development of Imitation Skills*

It has been suggested that there are three distinct categories of action to be modeled: bodily movements, simple actions on objects, and complex actions on objects. Further, with increasing complexity there is also an increase in the number of mechanisms of social learning that could underlie copying of each type of action (Want & Harris, 2002). For example, to imitate complex actions on objects (e.g., using a tool to obtain an object) children can imitate the behavior, the style, or the end point, which some also refer to as the goal. Thus, there is much more to imitation than simply moving an object. An example of these components in the everyday play of young children is

seen in a child pushing (style) a car and crashing (behavior) it into a block tower to knock it over (end point/goal). Another child or adult may use a different style (spinning the car) along with the crashing behavior to knock the tower over, thus allowing the child an opportunity to explore other affordances of objects and learn about the world in new ways. Thus, the child's play repertoire and understanding of the world is expanded. However, what is often observed in the play of young children with ASD is repetitive play, such as only driving the car into the blocks to knock them over, and not incorporating the style of other's play. Also, children with ASD may display rigidity in their play. Thus, a child may have one way that they insist is the only way to play with particular toys. Then the child is likely to become upset when the actions are changed and violate their rigid play scheme. In this way, young children with ASD may be interacting with objects in their world, but not be learning about their world by observing and imitating all of the components of another person's actions. When this child starts playing with other children, the child's peers may tire of this repetitive type of play, thereby reducing the child's opportunities for social interactions.

### *Overview*

This literature review starts with a discussion of how imitation begins in infancy and continues to develop throughout early childhood and then moves on to describe some of the more sophisticated questions that are being examined in the typical literature regarding imitation. Next, this review discusses the literature on imitation difficulties in individuals with ASD, current theories related to imitation impairments in ASD, and other important early developing skills that may be important to consider along with atypically developing imitation skills in ASD. Finally, this review concludes with the

integration of knowledge from the literature on typical imitation development with knowledge of imitation difficulties in ASD. This combination of the typical and ASD literature produces the goals of this study which attempt to explore the process of imitation in a different way than has been done previously in young children with ASD.

*What is Imitation?*

In the literature, “imitation” has been a broadly defined term used to refer to all instances of copying behaviors. However, imitation is not one behavior. Rather, many different behaviors or skills may be involved in imitation. There has been some argument by comparative psychologists that imitation refers specifically to situations in which one: (a) understands the goal of a model’s actions, (b) copies the specific actions the model used, and (c) reproduces the result modeled. It is argued that defining imitation in this way can be useful by helping to distinguish between “emulation” [instances in which one (a) understands the goal of a model’s actions and (c) reproduces the modeled result yet not (b) copying the specific actions that the model used] and “mimicry” [instances in which one (b) copies the actions used to achieve (c) the result of the actions without (a) understanding the goal or why specific actions were performed] (Nielsen, 2006).

Just as our understanding of different mechanisms or skills involved in imitation is expanding while at the same time becoming more refined, so is our knowledge about the developmental process of imitation in young children. During the first two years of life, children show a developmental increase in action copying and show a preference for imitating actions over results of the action (Tennie, Call, & Tomasello, 2006). Over the next two years of life, toddlers exhibit tendencies toward perfect imitation of both actions and results, including elements of nonfunctional significance (Whiten, Custance, Gomez,

Teixidor, & Bard, 1996). One possible explanation for this is the development of social-cognitive skills during this time which promote shared experiences with objects and other people (Nielsen, 2006). However, this developmental increase in fidelity of imitative behaviors has not been found to continue into adulthood, as adults have been found to be less imitative as compared to children (Horowitz, 2003).

Across species, Call, Carpenter, and Tomasello (2005) examined whether chimpanzees and 2-year-old children would copy demonstrations of how to open a tube, when shown the action only, the result only, both the result and the action, or no demonstration. The two methods of opening the tube were also combined with a “style” component of the action which was not necessary for opening the tube. Call et al. (2005) found that chimpanzees mostly copied the environmental results, suggesting emulation, while the 2-year-old children often reproduced the demonstrator’s actions. The authors suggest this reflects imitation while others may categorize this as mimicry. Additionally, the authors indicate that in the “social” conditions in which the demonstrator’s actions were shown, the children opened the tube more often by reproducing specific actions seen, including the specific style. Thus, which components of an action are imitated varies by species. Human children exhibit behaviors more similar to what has been defined as imitation rather than emulation. This was evident when they imitated a component, such as style, that is not necessary to the task. These results suggest that imitation serves a social-cognitive function for human toddlers (Nielsen, 2006).

### *Style in Imitation*

One possible attempt to differentiate mimicry from emulation has been to examine imitation of the “style” of an action used to achieve a particular goal. In the

literature, “style” has not been well defined, but can be thought of as the bodily expressions or movements that are incidental or implicit to achieving behavioral goals or the particular characteristic or way that a person performs a behavior. Meltzoff and Moore (1997) note that “Human acts themselves have characteristics that can be imitated such as speed, duration, and manner” (p. 189).

While infant imitation appears to have a bias toward goal-directed actions, infant imitation is not always goal-directed. Infant imitation may also reflect preferences for novelty and relevancy in information communicated through the imitative act rather than goals. Southgate, Chevallier, and Csibra (2009) found that infants used a toy animal to imitate action style (hopping or sliding the toy animal) rather the goal (placement in a toy house) when the goal was perceived as old information or had received previous demonstration. Thus, these authors suggest that there is more to imitation than re-enacting goals.

To examine the actions young children imitate, Wagner, Yocom, and Greene-Havas (2008) used an imitation choice task during directed motion events with 34 2- and 3-year-olds. Directed motion events can be thought of as actions involving an object that are made of several components. These components include a “path” or direction of motion, “manner” or type of motion, “source” where the motion begins from, and a “goal” that a motion is directed toward. “Manner” in this experiment involved the examiner either hopping or sliding a doll. In a direct imitation condition, children observed the examiner’s actions and had the opportunity to imitate the actions directly. However, in the other condition, imitation choice, children could either imitate the goal or the path of the examiner’s behaviors but not both at the same time. For example, the

experimenter moved a doll down a ramp and into a bowl whereas the child's bowl was situated at the top of the ramp rather than the bottom forcing the child to choose to preserve the path (i.e., direction of motion downward) or the goal (i.e., placing the doll in the bowl). See Figures 1 and 2 for illustrations from Wagner et al (2008).

Wagner et al. (2008) found that these young children were capable of imitating directed motion events as they replicated the modeled behavior during the direct imitation condition. During the imitation choice condition, children showed a preference for preserving the path component at the expense of the goal. Manner was accurately imitated 75% of the time. Correctly imitating manner was found to be more likely when the path was imitated rather than the goal. Wagner et al. (2008) suggest that the way that information is structured within events is important and that the path and manner components provide maximal information for children through the structure they afford. Additionally, Wagner et al. (2008) hypothesized about the possible connection between encoding actions with path and manner information and encoding and organizing grammatical information using linguistic information in the English language, such as skipping (manner) on the road (path). As a result of the way that the English language is constructed, information about manner is typically communicated through the verb in the sentence and path information is communicated through prepositional phrases (Wagner et al., 2008). In languages such as English, emphasis is placed on manner information via the verb and its early placement within the sentence structure. Thus, imitation examined through these directed motion events can have implications for multiple domains of development including social-cognitive development and language development, which are areas of impairment for young children with ASD.

*Autism: What is Imitated?*

Imitation has the ability to provide perspectives on both cognitive and social processes (Meltzoff & Moore, 1983, 1989). From this point of view, impaired imitation can be a factor in both the cognitive and social impairments in ASD. Imitation impairments in ASD may lead to atypical developmental trajectories involving multiple cognitive and social domains or impairments in learning from the early social environment (Rogers & Pennington, 1991). Much of this early learning occurs implicitly through imitation and may lead to continued atypical development in social, communication, and cognitive domains.

Despite the overall belief that imitation is impaired in ASD, research findings from controlled studies of imitation in autism have found mixed results depending on the domain of imitation examined (e.g., goal emulation, facial mimicry, dynamic style, gestures, actions on objects; see Rogers & Williams, 2006, for a review).

Within the domain of actions on objects, Hobson and Lee (1999) examined copying an actor's goal by distinguishing form from function of the imitation and found an autism-specific deficit in mimicking the dynamic style of a goal-directed action on an object. Hobson and Lee's (1999) study was one of the first to examine imitation of style in ASD, although with adolescents rather than young children. They found that fewer adolescents with autism copied the style of another person's novel nonsymbolic actions as compared to a comparison group of age and verbal ability matched adolescents without autism. For example, adolescents were shown how to scrape two objects together to make a sound and were asked to copy this action. Adolescents with autism were able to perform the same goal-directed action (e.g., move a stick across a wooden pipe-rack),

but failed to mimic the style (e.g., gentle or harsh movement to strum the stick across the wooden pipe-rack) with which the action was performed. In 2008, Hobson and Hobson expanded on this research and found that children with autism (mean chronological age of 11 years; mean verbal mental age of 6 years) were able to copy relatively complex goal-directed actions (e.g., depress a lever to connect a keychain to a hook) similarly to children without autism, but were significantly less likely to imitate the style of goal-directed actions, even simple actions (e.g., roll a tool across playdough gently or forcefully), especially when the style was incidental to achieving the goal.

This line of previous research suggests that even within copying goal-directed actions, which previous research indicated was not impaired in individuals with ASD, there is an additional component of style that has been found to be impaired. Thus, it appears that two separate mechanisms underlie imitation of actions; one is explicit processing resulting in an effortful, conscious matching of outcomes and the other involves implicit processing resulting in automatic copying of the style that accompanies the action (Hamilton, 2008).

The results of other studies of actions on objects continue to add to contradictory findings in this area. When reviewing goal emulation using actions on objects, Hamilton (2008) concluded that individuals with ASD copied what they consider to be the actor's goal and found no autism-specific deficits. Specifically, Hamilton (2008) reported that children with autism performed similarly to typically developing children on goal-directed imitation tasks.

Thus, while some studies have found intact imitation abilities in individuals with ASD, it is difficult to know if style is the same. For example, even when some forms of

imitation may look unimpaired or differentially impaired due to the use of compensatory strategies, this is often not enough to overcome the clinical sense that there is still something missing from the social or communicative content during an interaction even when a behavior is imitated. For example, young children with ASD may not naturally smile in response to another person's smile, which is a skill known as a responsive social smile. Thus, in therapy a child may be taught this social behavior. However, in practice, although the child has learned to smile in response to another person's smile, the child's timing may be off (i.e., late) or not well coordinated with other behaviors, such as eye contact. Thus, while the child has learned the behavior, there is still something that is not quite right about how it is being implemented by the child.

Knowledge regarding imitation difficulties in individuals with ASD has greatly increased from the earliest hypotheses that they do not possess the ability to imitate at all to the more refined hypotheses regarding difficulties in certain areas or domains of imitation, but not others. Intriguingly, while children with ASD have weaker overall imitation skills than other children, the pattern of their performance has been shown to be similar to children with typical development and children with developmental delays across different imitation domains (Stone et al., 1997) with imitation of body movements being more difficult than actions with objects. These differences have been found to be most striking in spontaneous interactions rather than during elicited imitation (Ingersoll, 2008). Thus, research on imitation in ASD is beginning to be able to study more subtle aspects of imitation borrowing from the increasingly sophisticated knowledge of imitation in the infant literature.

In children with ASD, imitation skills have been related to several different areas of development depending on the type of imitation task. Specifically, McDuffie et al. (2007) found strong correlations between different types of motor imitation and specific areas of development in young children with ASD after controlling for general cognitive level. For these children, performance on directly elicited imitation was related to their attention-following abilities. Additionally, non-elicited imitation (i.e., observational learning) was related to both attention-following and nonimitative fine motor skill. Finally, spontaneous imitation during interactive play was associated with social reciprocity. Additionally, imitation of body movements has been associated with expressive language skills while imitation of actions with objects has been associated with play skills in children with ASD (Stone, Ousley, & Littleford, 1997). This suggests that different processes may underlie imitation of body movements and actions with objects. The link between imitation of body movements in this study and expressive language makes sense given the link between gestures (body movements) and expressive language development as well as the temporal development of imitation and language skills including gestures. Thus, any study of imitation in ASD needs to clearly specify both the type of imitation being examined and the specific ASD symptomatology that may be related to these imitation skills.

#### *Theories Regarding Imitation Difficulties in ASD*

Although imitation impairments in ASD have been studied, underlying mechanism(s) have yet to be identified. However, many theories exist. While some earlier theories lack enough data to support full explanations of imitation difficulties on their own, there are two more recent theories currently being explored.

The first theory is Rogers and Pennington's (1991) self-other representation hypothesis. This theory, which posits difficulties coordinating representations of self and other, has enough support in the literature to be considered a possible hypothesis for the imitation difficulties in children with ASD (Rogers & Williams, 2006). This hypothesis suggests that there are two components of imitation, cross-modal representation extraction of correspondence between self and other and executive functions. Cross-modal representation allows one to recognize the equivalence between the acts that they see others perform and the acts they perform themselves. Thus, one's own actions as felt and the actions as seen in others can be linked. Imitation and the ability to represent oneself and another person both require translating between one's own perspective and that of another. When imitating, one must convert an action from another's perspective to one's own perspective. Thus a difficulty in self-other representation may be fundamental in the imitation difficulties observed in ASD. Neurologically, this type of impairment may be linked to the prefrontal cortices of the brain as this area is thought to be related to executive function abilities (Rogers and Pennington, 1991).

A second theory which has become increasingly popular suggests that impairments in imitative performance in ASD are caused by a dysfunctional mirror neuron system. Mirror neurons were first found in the ventral premotor cortex and inferior parietal lobe of monkeys (Rizzolatti & Fabbri-Destro, 2010). They obtained this name as it appeared that these neurons fired both when the monkey performed a specific action and when the monkey was observing someone else execute the same action as if the observed action was mirrored or simulated within the monkey's own brain. Some research has found impaired imitation performance on tasks involving social mirroring of

facial expressions and intentional attunement in individuals with ASD being consistent with disturbances in the mirror neuron system (Gallese, 2006; Iacoboni & Dapretto, 2006). However, the results of studies examining activation of the mirror neuron system have been inconsistent with regard to where impairments are located neurologically (Dapretto et al., 2006; Williams et al., 2006) and if the mirror neuron system is impaired in individuals with ASD (Leighton, Bird, Charman, & Heyes, 2008).

Alternative explanations for these discrepancies within the mirror neuron system may exist as imitation is a broad and intricate phenomenon, which may involve more processes than the mirror neuron system alone can support. While weak performance on a voluntary imitation task was found in adults with ASD as compared to adults with typical development, they also exhibited weaker performances on non-imitative versions of the same task possibly indicating impairments in non-specific abilities required for imitation rather than a mirroring deficit (Leighton et al., 2008). Imitation impairments in ASD may also reflect a lack of sensitivity toward environmental or social cues that help them identify what to imitate (Landry & Bryson, 2004). Thus, the mechanism is not well-understood. Perhaps this is a result of theories that are based on previous ideas of poor overall imitation, which need to be revised to reflect a more complex view of the strengths and weaknesses in imitation that individuals with ASD possess, as is being done in this study. Thus, if supported, it is hoped that this research will provide new information to develop a more accurate theory regarding imitation impairments in ASD and thereby potentially “reframe” how we view imitation in ASD.

*Role of Executive Function in Social and Cognitive Impairments in Young Children with ASD*

Executive function skills are important to consider when examining imitation. The link between executive function and imitation is central to Rogers and Pennington's (1991) self-other representation hypothesis. Specifically, with this hypothesis, imitation impairments are thought to be secondary to planning or executive function difficulties.

When individuals have difficulties with behavioral, cognitive, social, or emotional development or learning, sometimes difficulties in executive functioning can be a contributing factor. Executive function (EF), as an umbrella term, has generally been defined as referring to a set of abilities that allow individuals to solve a problem or achieve a particular goal (Griffith, Pennington, Wehner, & Rogers, 1999). This broad construct has been broken apart into a variety of functions or abilities including: inhibition, working memory, inhibition, set-shifting/cognitive flexibility, planning, and generativity. Traditionally, these functions have been associated with frontal structures in the brain, particularly the prefrontal cortex. Executive functions encompass skills that begin to develop in the first years of life (lower-order skills such as working memory and inhibition) and begin to more fully develop later in childhood and adolescence (higher-order skills such as planning and self-monitoring).

Research with school-aged, adolescent, and adult participants with ASD has found significant deficits in EF as compared to a diverse set of control groups (see Hill, 2004; Pennington & Ozonoff, 1996 for reviews). Thus, a primary EF deficit hypothesis of autism has been posited (Pennington & Ozonoff, 1996).

Examining EF in younger, preschool-aged children has historically been more difficult both in typically developing children and children with ASD, but is possible if developmentally appropriate tasks are used. Two important EF components have been identified as important during this stage of development, namely response inhibition and set shifting. In contrast to the EF deficits found in older children, adolescents, and adults, EF research with younger, preschool-aged children with ASD has largely failed to demonstrate specific EF deficits. Griffith, Pennington, Wehner, and Rogers (1999) administered a large battery of EF tasks to 40- to 61-month-old children with ASD and a chronological age, verbal mental age, and nonverbal mental age matched control group of children with heterogeneous clinical disorders, including Down syndrome, speech/language delays, and general cognitive delays. On all eight EF tasks administered, the groups performed similarly and when differences were significant they indicated that children with autism performed better than children in the control group. Thus, Griffith et al. (1999) hypothesized that performance on EF tasks falls behind mental age level in children with developmental disorders, rather than this profile being specific to children with autism. Later, Dawson and colleagues (2002) examined EF abilities in 3- and 4-year-olds with ASD as compared to 3- to 4-year-old children with developmental delays and 12- to 46- month old children with typical development matched on mental age. Children with ASD in this study performed similarly to the children in both comparison groups on all five executive function tasks administered. The tasks administered included a delayed nonmatching to sample task, object discrimination reversal task, the A not B task, A not B with invisible displacement task, and a spatial reversal task. Both Griffith et al.'s (1999) and Dawson et al.'s (2002) results suggest that at this young age, autism is

not associated with a unique pattern of executive function impairment and that it is possible that these impairments are not evident until later in development. If true, then impaired executive function may not be a precursor of poor imitation skills as originally hypothesized. However, given the hypothesized link between imitation and executive function, it is important to examine executive function in a study of imitation skills in children with ASD.

### *Summary*

Imitation has the ability to provide perspectives on both cognitive and social processes (Meltzoff & Moore, 1983, 1989) and as such, impaired imitation can be a factor of both cognitive and social impairments in ASD. Yet, the framework for examining imitation that exists in the typical literature has not yet been applied to understanding imitation and related social-cognitive processes in individuals with ASD. Additionally, imitation in ASD has not been examined using the more detailed taxonomy currently being used by comparative psychologists (Rogers & Williams, 2006).

Research into the development of imitation in children with typical development continues to expand and has become more refined. Rather than ask Piaget's question of whether young children can imitate, recent research asks what types of behaviors are imitated, how imitation occurs, and under what circumstances does imitation occur. The role of imitation and subtle difficulties associated with imitation in children with ASD have not yet been explored with as much depth as in the typical literature. To date, most of the research in ASD has focused on whether imitation occurs rather than the more refined questions being examined in the typical literature. Thus, the mixed results found in the ASD literature may be due, in part, to the fact that researchers have not been asking

detailed enough questions, such as how children with ASD use and learn from imitation. Further, the lack of specific research examining the imitation strengths and weaknesses in young children with ASD has limited the ability of researchers to develop and test overall theories regarding imitation impairments in ASD. Finally, while the present study includes children with ASD in the age range where executive function impairments are not consistently found, some measure of executive function may be necessary in order to examine how executive function and imitation are related in this group of children.

### *Current Study*

The current study assessed the abilities of young children with ASD using a subtle imitation paradigm that has been successfully used to understand imitation skills in young children with typical development. Specifically, the present study examined what behaviors children with ASD choose to imitate and which components of a simple action involving an object are most salient. The current study also explored the potential impact of other factors on choosing what to imitate, such as executive functioning as well as language and developmental level. Ideally, this type of study would have been conducted in toddlers with ASD to match the age of the children being studied in the typical development literature on these types of tasks. However, given the difficulty of diagnosing ASD prior to the third year of life and the difficulty of conducting experimental protocols with very young children with ASD, the focus of the present study was on preschool children (chronological ages 3-5).

The specific focus of this study was on how preschoolers with ASD extract information from social partner's actions and whether they focus on path, style, or goal components. This research employed a methodology (i.e., comparing directed imitation

with an imitation choice paradigm) based on the work of Wagner et al. (2008). The two conditions used in the present study were based on Wagner et al.'s (2008) direct imitation and choice imitation methods. In the first condition, the exact imitation condition, children observed the examiner's actions with objects on a playset. The children then had the opportunity to imitate the actions exactly as observed with an identical playset. The second condition that was used was based on Wagner et al.'s (2008) imitation choice task. In this condition, children observed the examiner's actions with objects on a playset as in the exact imitation condition. However, in this condition the playsets were similar, but not identical. Thus, the children were prevented from being able to imitate all aspects of the examiner's behavior and had to choose which to imitate (style, path, or goal). Using the direct imitation and choice imitation tasks in conjunction with one another offered certain advantages; for example the imitation choice condition precludes exact imitation and focuses on what one chooses to do rather than what one fails to accomplish. Additionally, using directed motion events allowed several different components of an imitative act to be distinguished from one another.

Within these two conditions there were three aspects of imitation that were enacted: style, path, and goal. These aspects were also based upon Wagner et al.'s (2008) task design in which style was either hopping or sliding, the path was either up or down, and the goal was either in or on a cup. Additionally, this style component may be complimentary to Hobson's (Hobson & Lee, 1999; Hobson & Hobson, 2008) concept of the "style" with which actions are executed (gentle or forceful). It is important to clarify the semantics surrounding the term "goal" in the context of the current study. Specifically, "goal" will be used to refer to the predetermined final action that

corresponds to a particular location on the playset rather than an individual's personal goal or intention in producing specific actions.

It was hypothesized that children with ASD would have difficulty imitating the style of the examiner's actions. Further, the current study may provide insight and knowledge into how preschoolers with ASD learn through imitation and has wide implications for interventions for preschoolers with ASD.

#### *Research Questions*

1. Do young children with ASD imitate all aspects of an imitative action on an object at the same rate as typically developing children?
2. When exact imitation is precluded in the choice condition, do preferences in the aspects young children with ASD choose to imitate change?
3. Is there an impact of more general imitative ability or executive functioning on imitative performance in this experimental task?.

## Methodology

### *Participants*

Twenty-five children with a diagnosis of ASD participated in the current study (see Table 1 for demographic and diagnostic information on all three participant groups). The mean chronological age for these children was 43.48 months (SD = 13.34; Range = 25 - 68 months). All participants in the ASD group received a previous diagnosis of an autism spectrum disorder, which was confirmed using the Autism Diagnostic Observation Schedule – Generic (ADOS-G; Lord et al., 2000) that is based on criteria in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR: American Psychological Association, 2000). The ASD group consisted of 19 males and 6 females. This sample included approximately 4:1 males to females, which is consistent with report of the rate of diagnosis of ASD by gender (Fombonne & Chakrabarti, 2001; Fombonne, 2001, 2005), which prevented examining gender differences.

The ASD group was recruited through preschool or clinical service programs that provide early intervention services to children diagnosed with ASD. Eligibility requirements for participation included having an existing diagnosis of an autism spectrum disorder (i.e., autism, Asperger's Syndrome, or PDD-NOS), a receptive language raw score that was equal to an age equivalence score equal to or greater than 18 months, and a chronological age between 18 and 68 months.

Forty-one children with typical development participated in the current study and were recruited from a university preschool program as well as from local community preschool programs. Two groups of children with typical development were created such that one group was matched to the ASD group on chronological age (i.e., Age match) and other group was matched to the ASD group on receptive language raw score from the Mullen Scales of Early Learning (i.e., Language match). There was some overlap in participants between the two groups of children with typical development ( $N = 16$ ). In addition, several analyses were conducted using the entire sample of children with typical development to maximize statistical power (i.e., All typical). As a whole, the mean chronological age of children in the groups with typical development was 41.29 ( $SD = 12.16$ ; range = 21 – 67 months). See Table 1 for demographic information on both groups of children with typical development separately.

One important methodological challenge in conducting research on ASD is how best to capture differences and compare performance. There is no one solution to this issue. However, group matching designs are commonly applied. Yet, there is also no best way to match groups due to variability in the profile of strengths and weaknesses in individuals with ASD, specific task demands, and specific research questions (Burack, Iarocci, Flanagan, & Bowler, 2004). Matching on chronological age, while informative, does not allow researchers to tease apart task differences from differences due to level of development or cognitive ability. Thus, as imitation abilities increase as young children develop, having a control for development was also important. Given Wagner et al.'s (2008) hypothesis that this specific type of imitation task draws upon encoding and organization of grammatical information, this was a specific task demand to consider. Young children with ASD tend to exhibit a language profile in which receptive language

abilities are lower than are expressive language abilities. Thus, matching on receptive language was important in addition to matching on chronological age as a conservative means of understanding potential group differences.

### *Diagnostic Measures*

*Autism Diagnostic Observation Schedule – Generic (ADOS-G; Lord et al., 2000).*

The ADOS-G was used to confirm the diagnoses for participants with ASD and provide diagnostic information regarding behavioral symptomatology in the areas of social interaction skills, communication, play, and repetitive behaviors. It is a 30-45 minute play session that measures a variety of behaviors associated with ASD including stereotyped/idiosyncratic use of words or phrases, unusual eye contact, quality of social overtures, initiation and response to joint attention, and unusual sensory or repetitive behaviors. Scores for individual items range from ‘0’ to ‘3’, with ‘0’ indicative of no unusual behaviors and ‘3’ indicative of behaviors highly consistent with ASD. Diagnosis is determined by using an algorithm to obtain a total score with specified cut-off scores needed for a diagnosis of either autism or autism spectrum. Research has shown that the ADOS-G has strong correlations of overall inter-rater reliability ranging from .82 to .93 in all 3 domains and possesses strong diagnostic validity in that it differentiates ASD from non-spectrum disorders well.

*Childhood Autism Rating Scale, Second Edition, Standard Version Rating*

*Booklet (CARS2-ST; Schopler, Van Bourgondien, Wellman, & Love, 2009).* Children in all groups received a clinician rating of their behavior using the CARS2-ST based on a 5 minute free play session. The CARS2-ST contains 15 items addressing functional areas with each item rated using a 4-point response scale. Severity of autism symptomatology is determined by using specified cut-off scores. The CARS2-ST has a

total score internal consistency estimate of .93 and has a correlation value of .79 to ADOS scores, which indicates a reasonably strong relationship between clinician rating on these two different measures. For children in the ASD group the CARS2-ST provided an additional and current measure of symptom severity for correlational analysis. For children with typical development, it was completed to provide an additional verification that they were not exhibiting symptoms indicative of ASD.

### *Cognitive and Imitation Measures*

*Mullen Scales of Early Learning (Mullen; Mullen, 1995).* The Mullen was used as a measure of children's nonverbal abilities as well as their receptive and expressive language abilities. It is a standardized developmental measure for children between birth and 68 months of age and consists of five subscales: gross motor, fine motor, visual reception (i.e., nonverbal ability), receptive language, and expressive language. The gross motor subscale was not administered for the current study. The raw score from the receptive language subtest was used to match children in the ASD group to children with typical development in the Language Match group. Raw scores are used to calculate age equivalents while standardized T-scores are converted to obtain the Early Learning Composite. This Early Learning Composite provides an estimate of a child's overall developmental level. There is evidence that the Mullen demonstrates good construct validity in that a child's raw score increases as their chronological age increases. Also, the Mullen demonstrates good concurrent validity with other well-known developmental tests of cognitive, language, and motor development.

*Motor Imitation Scale (MIS; Stone et al., 1997).* The MIS measures motor imitation of actions on objects and body gestures. The MIS consists of 16 single-step motor imitation activities; 8 items that elicit motor imitation with objects (comprised of

4 meaningful actions and 4 nonmeaningful actions) and 8 items that elicit body movements/gestures without objects. For all 16 items, the child is given 3 opportunities to imitate the examiner's action. Responses are scored as '2' – pass, '1' – emerging, and '0' – fail on the basis of the quality and accuracy of the child's response. Thus, a child's score on imitation with objects items and body movements can range from 0-16 with total scores ranging from 0-32. The total MIS score has an internal consistency standardized alpha coefficient of .87 and test-retest reliability of the total MIS score is .80 (Stone et al., 1997). The MIS motor imitation of actions on objects items provides a criterion level for imitation skills in the children.

*Executive Functioning.* Two brief tasks examining executive functioning were administered.

Gift delay (wrap). This is a response inhibition or delay of gratification task in which the child is asked not to look while the examiner noisily wraps a present for 60 seconds. This is a task that is appropriate for children approximately 22 months of age and older (Garon, Bryson, & Smith, 2008). This task was coded 1 for 'pass' and 0 for 'fail,' with failure resulting from peeking before the end of the 60 seconds. Children's behavior during the task is also coded to yield a categorical "peeking score" (0 = turning fully around to peek, 1 = peeking over the shoulder, 2 = no attempt to peek), the total number of times children peeked, and latency to first instance of peeking over their shoulder or fully turning around (with full compliance coded as 60 seconds).

A-not-B. This is a response shifting task for children ages 6 months and older (Garon, Bryson, & Smith, 2008). In the sight of the child, a desired object is hidden under cup A and the child reaches for the desired object after a delay of 5 seconds. If the child reaches correctly the object is retrieved, but if the child reaches incorrectly the

examiner shows the child the location of the reward. Once the child has successfully retrieved the object for two consecutive trials, the object is then hidden under cup B. Once the child has successfully retrieved the object on the reversed side under cup B for two consecutive trials the delay will be increased to 10 seconds with the entire process starting with location A again. The percent of trials in which the child reaches correctly for location A at 5 seconds, the percent of trials in which the child correctly reversed to location B at 5 seconds, the percent of trials in which the child correctly reached at location A at 10 seconds, the percent of trials in which the child correctly reversed to location B at 10 seconds, and the number of errors before success at location B is recorded. Starting side was varied randomly across children within groups. If the child could not correctly locate the desired object in four consecutive trials, the task was discontinued.

#### *Style, Path, and Goal Imitation Task*

*Apparatus.* The style, path, and goal imitation task used equipment similar to the apparatus described in Wagner et al. (2008). Refer to Figures 1 and 2 for illustrations from Wagner et al. (2008) and refer to Figures 3, 4, 5, and 6 for examples of the playsets used in this study. Similar to Wagner et al. (2008), the playsets used in this task were made of foam-core materials that were reinforced for extra stability and durability using solid foam pieces covered in felt and duct tape. Due to the number and different configurations of playsets needed, parts were interchangeable yet fastened to one another so as to be easily transportable and efficient.

The playsets were comprised of a black ramp that provided a path between a black base and a black ledge. There were two types of playsets that varied only by the shape of the ramp, either straight or wavy (see Figures 3-6). Two playsets that varied by

the ramp shape were used in order to increase the number of trials that were presented while decreasing boredom with the playsets and task. Secured on the top ledge and the bottom base were two small containers of different colors that serve as the goals. One container was inverted to provide an area for an object to be placed on top of it and one container was upright so that an object can be placed inside of it.

This study had two separate conditions (exact imitation and choice imitation). During both the exact and choice imitation conditions the examiner and child had their own playset. In the exact imitation condition the playsets were identical (see Figures 3 and 4), but in the choice imitation condition the location of the containers was reversed to preclude exact imitation (see Figures 5 and 6). Each child played with one straight ramp playset in an exact imitation condition, one straight ramp playset in a choice imitation condition, one wavy ramp in the exact imitation condition, and one wavy ramp in the choice imitation condition. Order of presentation of the straight and wavy ramps was counterbalanced across children.

With each of these playsets, four imitation trials were presented. These four imitation trials constituted a block. Each trial was composed of an action component that had a style (hop or slide), a path (up or down), and a goal (in or on a cup). Thus, there were four possible combinations of action components that occurred with each playset. See Table 2 for a sample illustrating the four possible combinations of actions per block resulting in four trials per block. The four possible trial combinations were presented once each in random order within each block.

As there were two playsets per condition and two conditions, a total of four blocks of trials were be presented. With each block having four trials within it, a total of 16 individual trials were administered to each child. Thus, eight trials occurred in the

exact imitation conditions and the other eight trials occurred in the choice imitation condition.

In order to orient the children to the nature of the imitation task, a similar type of exact imitation task was presented to children as a warm-up to the task. This warm up task was a bridge upon which a different set of simple style, path, and goal components was performed. Pilot testing revealed that the bridge condition yielded different performance from the ramp conditions used in the test conditions. The bridge was designed with two red foam ledges which were connected by a red bridge. Each ledge had a different type of goal with which an action was modeled, such as putting under or through. The path was modeled as left or right and the styles included moving forward and backward or up in a circle. See Figure 7 for sample pictures of this bridge warm-up playset. The warm-up consisted of a block containing two imitation trials.

The objects that were used in the warm-up and test conditions to enact the imitation acts were small stuffed animals including a monkey, tiger, and hedgehog. For each child, they used a different animal on the warm-up bridge, straight ramp playset, and wavy ramp playset, resulting in the use of all three animals. Animals were randomly assigned for use with each playset.

#### *Demographic Questionnaire and Preschool/Intervention History*

A demographic questionnaire was given to each parent/guardian. The questionnaire was used to gather information regarding ethnicity; parental educational background; household income; current medications; and pre-existing psychiatric history, including diagnosis of ASD. This questionnaire also included information regarding the child's preschool and intervention history to gather information about the type and length

of the preschool program the child has attended as well as the type, length, and provider of any intervention services.

### *Procedure*

Participants were scheduled for two to three sessions. Prior to or at the first session, parents of participants signed a consent form allowing their child to participate in the research study in addition to completing the demographic questionnaire and preschool/intervention history form. In the first session, children were asked to give verbal assent to participate. If a participant with ASD had not received a ADOS-G as part of a research study or clinical service provision at the University of Alabama (UA) Autism Spectrum Disorders (ASD) Clinic, then an ADOS-G was administered in that child's first session in order to determine study eligibility, resulting in a total of three sessions for these children. During the first research session (second session for a child with ASD if an ADOS-G needed to be completed during the initial session), children completed 2 trials with the warm-up bridge, the first set of four trials of the experimental imitation task exact condition, the first set of four trials of the experimental imitation task choice condition, the MIS, appropriate items from the Mullen Visual Reception and Receptive Language scales, and an executive function task. The child's last session entailed 2 trials of the warm-up bridge, the final set of four trials of the experimental imitation task exact condition, the final set of four trials of the experimental imitation task choice condition, appropriate items from the Mullen Fine Motor and Expressive Language scales, the remaining executive function task, and 5 minutes of free play time with a set of toys so that the CARS2-ST could be completed. See Table 3 for an example

of a possible schedule of the tasks that a participant completed during the testing sessions.

Each child was tested individually with the examiner in a quiet room at their preschool or at the UA ASD Clinic. Parents were not present in the room during testing. The experimenter and child were seated next to each other during the experimental imitation task. While children were given the opportunity to see the stuffed animal and the playset they would be using, they were not allowed to use the animal on the playset before trials were presented in order to try to minimize children's ability to form prepotent responses and to help standardize the amount of time children were exposed to the playsets. Children were introduced to the stuffed animals that would be used in the task and told that he or she would watch the animal do something on the examiner's playground (playset) and then he/she would have a turn to make the stuffed animal do the same thing on his or her playground. The examiner started her turn by saying, "it's my turn, watch." Each trial involved the examiner enacting an action that included a style (hopping or sliding), path (up or down the ramp), and a goal (placing the animal onto or into one of the two goal containers). The examiner's movements were standardized such that the animal's action on the ramp lasted a few seconds and the animal would remain at the goal container for a few seconds so that the amount of time the style, path, and goal components were presented was approximately the same. Next, the examiner handed the animal to the child. The children were given encouragement to participate from the examiner saying, "it's your turn, show me on your playground." If the child was inattentive or reluctant to take a turn, the examiner modeled that trial one extra time.

All participants were given stickers as a reward for their participation. Throughout all sessions, participants were given breaks to ensure that they were attentive and alert. Parents of children with ASD received a research report that outlined their child's performance on the standardized measures.

### *Coding*

For each trial, the child's imitation of path, style, and goal components was measured. Path was defined as the route going up or down the ramp, style was defined as the way in which the animal moved by hopping or sliding, and goal was defined as the final resting point of the animal either on or in the container.

Videotape recordings captured the child's hands and actions on the playset so that inter-rater reliability could be established between two coders. The examiner served as the main coder of the child's actions while the task was being administered. A second coder, who was blind to the child's diagnostic group membership, viewed recordings of the child's actions once the examiner's model had been cut out of the video in order to be blind to the specific trial that was being administered.

Children's task performance was coded for imitation of path, style, and goal event components using the same coding scheme employed by Wagner et al. (2008). Path was coded 'up' if the child moved the animal up the ramp and 'down' if the child moved the animal down the ramp. Style was coded as 'hop' if the animal did not remain in contact with the surface of the ramp and as 'slide' if the animal continued contact with the ramp. Goal was coded as 'in' if the child placed the animal at the upright cup and as 'on' if the child placed the animal at the upside down cup. In order to try to capture the possible variation in responses, when necessary, two additional codes were used to capture event

components as outlined by Wagner et al. (2008). ‘Omitted’ was used if a child failed to include any version of a component (e.g., if a child only placed the animal on/in the goal cup, the path and style components were coded as ‘omitted’). Finally, ‘multiple’ components were coded if the child enacted more than one version of a component in a serial manner (e.g., if the child placed the animal first in the cup and then immediately on the other cup, the goal component was coded as ‘multiple’). Additionally, for this study, whether the child reproduced the path or goal component was performed first was recorded and if a child enacted multiple components, the order in which they performed the components was recorded.

## Results

### *Interrater Reliability of Imitation Components*

Interrater reliability between two coders was examined. The examiner served as the first coder while the second coder was blind to the examiner's coding, the examiner's model, and the child's diagnostic group membership. Approximately 30% of the total trials distributed randomly across all participants were coded by the second coder. The overall interrater reliability for the raters was found to be very high,  $Kappa = 0.95$  ( $p < .001$ ). The two coders agreed on the actions of the children with ASD 95% of the time ( $Kappa = 0.92$ ) and agreed on the actions of the children with typical development 97% of the time ( $Kappa = 0.95$ ). The two coders agreed on the actions in the exact imitation condition 97% of the time ( $Kappa = 0.95$ ) while they agreed on the actions in the choice imitation condition 95% of the time ( $Kappa = 0.91$ ). With regard to the three components of imitation within the task, the two coders agreed on the style code 96% of the time ( $Kappa = .94$ ), the path code 95% of the time ( $Kappa = 0.91$ ), and the goal code 97% of the time ( $Kappa = 0.96$ ). The examiner's codes were used in subsequent data analyses.

### *Calculation of Imitation Task Component Scores*

For each participant, three imitation component scores (i.e., style, path, and goal) were calculated by computing the percentage of trials in which the child produced the imitation components just modeled in both the exact and choice imitation conditions. Thus, composite scores for imitation of style, path, and goal were calculated for the exact condition for all three groups of participants. The mean percentage of imitation

components for all three groups in the exact and choice imitation conditions is presented in Table 5. These composite scores were used in all subsequent analyses.

### *Analysis of Playset Differences*

Analyses were conducted in order to determine if there were any differences according to the type of playset, either straight or wavy, in the exact imitation condition. To compare the influence of playset between children with ASD and children matched on language ability, A 2 X 2 X 3 mixed factorial Analysis of Variance (ANOVA) was conducted in which the 2 diagnostic groups (i.e., ASD group and Language match) were a between-subjects variable and the 2 playsets (i.e., straight and wavy) and 3 components of imitation (i.e., style, path, and goal) were within-subjects variables. Effect size data is provided using Cohen's guidelines (i.e., a partial eta-squared ( $\eta_p^2$ ) of .01 is a small effect, .06 is a moderate effect, and .14 is a large effect).

There was not a statistically significant main effect of playset,  $F(1, 51) = 1.04, p = .31, \eta_p^2 = .02$ , which is associated with a small effect size. There were also no statistically significant two-way interactions between playset and diagnosis, [ $F(1, 51) = .003, p = .96, \eta_p^2 < .001$ ], or playset and component, [ $F(2, 50) = .03, p = .97, \eta_p^2 = .001$ ]. Finally, there was no statistically significant three-way interaction between playset, component, and diagnosis [ $F(2, 50) = .39, p = .68, \eta_p^2 = .02$ ].

To compare the influence of playset between children with ASD and children matched on chronological age, a second 2 X 2 X 3 mixed factorial ANOVA was conducted in which the 2 diagnostic groups (i.e., ASD group and Age match) were a between-subjects variable and the 2 playsets (i.e., straight and wavy) and 3 components of imitation (i.e., style, path, and goal) were within-subjects variables. There was not a statistically significant main effect of playset [ $F(1, 52) = 1.09, p = .30, \eta_p^2 = .02$ ]. There

were also no statistically significant two-way interactions between playset and diagnosis, [ $F(1, 52) = .001, p = .99, \eta_p^2 < .001$ ], or playset and imitation component [ $F(2, 51) = .12, p = .89, \eta_p^2 = .005$ ]. Finally, there was no statistically significant three-way interaction between playset, component, and diagnosis [ $F(2, 51) = .41, p = .67, \eta_p^2 = .02$ ].

As playset did not have an impact on performance, it was removed from the model in the analyses that follow.

#### *Comparison of Bridge Condition to Composite Experimental (Ramp) Conditions*

In order to evaluate if the bridge condition served as a warm-up task rather than teaching the task, within-subjects t-tests were conducted for all three groups in the exact imitation condition as the bridge was an exact imitation condition. For all three groups, imitation of style, path, and goal components in the bridge condition was significantly lower than imitation of those same components in the composite test conditions with the ramps (all  $p < .001$ ). These results suggest that the bridge condition worked differently than the ramp conditions. Thus, the bridge likely oriented the children to the task without teaching the task.

#### *Analysis of Performance in Exact Imitation Condition*

Because the choice condition required participants to choose whether to imitate path or goal, it was not appropriate to compare path and goal performance across the exact and choice conditions. However, style could always potentially be imitated in both tasks and thus performance could be directly compared. Thus, path and goal components of imitation were examined separately in the exact and choice conditions in the first set of analyses. Results of style imitation across both the exact and choice conditions will be presented later.

### *ASD and Language Match Group*

As can be seen in Table 5, the means for path and goal imitation in exact condition for the ASD and Language match groups were high and very similar; an ANOVA was conducted to explore the impact of each of these imitation components and diagnostic group on task imitation performance. A 2 X 2 mixed factorial ANOVA was conducted in which the 2 diagnostic groups (i.e., ASD group and Language match) were a between-subjects variable and the 2 components of imitation (i.e., path and goal) were a within-subjects variable. There was not a significant main effect of imitation component,  $F(1, 51) = .50, p = .48, \eta_p^2 = .010$ . There was not a significant main effect of diagnosis,  $F(1, 51) = .12, p = .73, \eta_p^2 = .002$ . There was not a statistically significant component by diagnosis interaction,  $F(1, 51) = .002, p = .97, \eta_p^2 < .001$ . The effect sizes of these analyses were very small to small supporting the interpretation that children in both diagnostic groups imitated both path and goal components and that no group differences were present.

### *ASD and Age Match Group*

The means for path and goal imitation presented in Table 5, revealed similar and high rates of imitation for the ASD and Age match group. A 2 X 2 mixed factorial ANOVA was conducted in which the 2 diagnostic groups (i.e., ASD and Age match) were a between-subjects variable and the 2 components of imitation (i.e., path and goal) were a within-subjects variable. There was no significant main effect of imitation components,  $F(1, 52) = .61, p = .44, \eta_p^2 = .012$ . There was also not a significant main effect of diagnostic group,  $F(1, 52) = .56, p = .46, \eta_p^2 = .011$ . Finally, there was not a statistically significant component by diagnosis interaction,  $F(1, 52) = .92, p = .92, \eta_p^2 < .001$ . The effect sizes associated with these analyses are very small to small supporting

the interpretation that children in both diagnostic groups imitated both path and goal components and that no group differences were present.

#### *Analysis of Path or Goal Preference in Choice Imitation Condition*

##### *Calculation of Experimental Imitation Task Path and Goal Preference Score*

In order to explore relations between the path and goal imitation components within the choice imitation task, a new variable was created. In the choice imitation condition, path and goal imitation were not independent of one another as the condition was set up such that either path or goal imitation would likely be precluded. Thus, a preference score was created for all participants by subtracting rate of goal imitation from the rate of path imitation. Therefore, positive scores indicated a path preference whereas negative scores indicated a goal preference.

##### *ASD and Language Match Group*

Looking at the means presented in Table 5, it appears as though children with ASD showed higher imitation of the goal component whereas the children in the Language match group showed higher imitation of the path component. To examine these performance differences, a one-way between-subjects ANOVA was conducted in the choice imitation condition. Results indicated a statistically significant difference between path and goal preference by diagnostic group,  $F(1, 51) = 16.66, p < .001, \eta_p^2 = .246$ , which is associated with a large effect size. Post-hoc analyses using Fisher's LSD indicated that children with ASD may have a slight goal preference ( $M = -.13, SD = .48$ ) while children in the Language match group showed a path preference ( $M = .33, SD = .34$ ).

To further examine the nature of these preferences, one sample t-tests were performed for each group comparing their scores to 0, which would indicate no

preference given the way that the preference score was calculated with positive numbers greater than 0 indicative of path preference, negative numbers less than 0 indicative of a goal preference. Thus, a score that is not significantly different from 0 would indicate no preference. For the group of children with ASD, their preference score ( $M = -.13$ ), was not significantly different from 0 indicating no path or goal preference,  $t(24) = -.14, p = .19$ . For the children in the Language match group, their preference score ( $M = .33$ ), was significantly different from 0 indicating a path preference,  $t(27) = 5.18, p < .001$ .

#### *ASD and Age Match Group*

The means in Table 5 suggest that children with ASD displayed a goal preference whereas children in the Age match group displayed a path preference. A one-way between-subjects ANOVA was used to evaluate these potential differences. Results indicated a statistically significant difference between path and goal preference by diagnostic group,  $F(1, 52) = 24.38, p < .001, \eta_p^2 = .319$ , which is associated with a large effect size. Post-hoc analyses using Fisher's LSD indicated that children with ASD may have a slight goal preference ( $M = -.13, SD = .48$ ) while children in the Age match group showed a path preference ( $M = .43, SD = .34$ ).

Again, to further examine the nature of these preferences, one sample t-tests were performed for each group comparing their scores to 0. For the group of children with ASD, their preference score ( $M = -.13$ ), was not significantly different from 0 indicating no path or goal preference,  $t(24) = -.14, p = .19$ . For the children in the Age match group, their preference score ( $M = .33$ ), was significantly different from 0 indicating a path preference,  $t(28) = 6.70, p < .001$ .

## *Style Differences Across Exact and Choice Imitation Conditions*

### *ASD and Language Match Group*

Looking at the means of style imitation presented in Table 5, it appears as though the group of children with ASD imitated style less often than did children in the Language match group in both the exact and choice conditions. A two-way between subjects ANOVA examined the impact of condition, either exact or choice, and diagnosis on imitation of style. There was a statistically significant main effect of condition on imitation of style,  $F(1, 51) = 5.84, p = .019, \eta_p^2 = .103$ , such that there was a greater rate of style imitation in the exact condition ( $M = .75, SD = .20$ ) than in the choice condition ( $M = .69, SD = .24$ ). In addition, there was a statistically significant main effect of diagnosis on imitation of style,  $F(1, 51) = 18.67, p < .001, \eta_p^2 = .268$ , such that children in the Language match group ( $M = .82, SD = .15$ ) had a higher rate of style imitation than did children with ASD ( $M = .62, SD = .23$ ). Both of these main effects were associated with moderate to large effect sizes. The interaction between condition and diagnosis interaction was not significant,  $F(1, 51) = 1.60, p = .21, \eta_p^2 = .030$ , and associated with a small effect size.

### *ASD and Age Match Group*

The means for style imitation appear as though children with ASD display less style imitation than the children in the Age match group in both the exact and choice conditions. To examine this, a second two-way between subjects ANOVA was conducted. There was a statistically significant main effect of condition on imitation of style,  $F(1, 52) = 7.54, p = .008, \eta_p^2 = .127$ , such that there was a greater rate of style imitation in the exact condition ( $M = .78, SD = .21$ ) than in the choice condition ( $M = .71, SD = .25$ ). In addition, there was a statistically significant main effect of diagnosis on

imitation of style,  $F(1, 52) = 23.55, p < .001, \eta_p^2 = .312$ , such that children in the Age match group ( $M = .85, SD = .17$ ) had a higher rate of style imitation than did children with ASD ( $M = .62, SD = .23$ ). These main effects are associated with moderate to large effect sizes. The interaction between condition and diagnosis was not significant,  $F(1, 52) = .96, p = .33, \eta_p^2 = .018$ , and associated with a small effect size.

### *Secondary Analyses with Covariates*

Due to concerns about loss of power related to the relatively small sample sizes in this research, initial analyses were conducted without the addition of covariates. Theoretically, executive function abilities, as measured by the A not B task or Gift Delay task, and overall imitation abilities, as measured by the MIS, could be important covariates to consider. Secondary analyses were conducted to examine the impact of these variables.

#### *Executive Functioning*

Children's performance on the A not B and gift wrap delay tasks were examined. Both tasks were analyzed for overall performance (e.g., number correct and time to peek) as well as for specific errors (e.g., errors on reversal trials and number of peeks). There were no significant differences by diagnostic group on any of these measures; all  $t(52) < 1.66$ , all  $p$ 's  $> .10$ . All variables, mean scores, and significance values for the groupwise matched groups are presented in Table 6.

#### A not B

Within each group of children, the number of trials on which the toy was correctly found after being hidden after each amount of delay was examined. Performance at each amount of delay was significantly correlated with performance at each of the other delays (all  $r$ 's  $> .25$ , all  $p$ 's  $< .04$ ). Because performance across the task was highly correlated, a

composite score of correct trials was created by averaging across each amount of delay in the task. This composite score for the correct choices made in the A not B task was the correlated with imitation component performance for each of the three groups of children. See Table 7 for these correlations.

For children with typical development in the Language and Age match groups, the A not B composite of correct choices was significantly positively correlated with imitation of the goal component in the exact imitation condition, ( $r = .38, p = .05$ ;  $r = .46, p = .01$ , respectively). There were no significant correlations with task performance for the children with ASD.

Within the A not B task, the number of errors made before a correct selection when the location of the toy was changed was also examined. Performance at each amount of delay was significantly correlated with errors at each of the other delays (all  $r$ 's  $> .50$ , all  $p$ 's  $< .001$ ). Thus, a composite score was created by averaging across all locations and amounts of delay.

There was no significant relation between this composite and any of the measures of imitation component performance on the task for any of the groups (see Table 7 for these correlations).

The number of errors made when the toy's location was changed was negatively related to correct choice performance ( $r = -.75, p < .001$ ).

### Gift Delay

For each child, the length of time they were able to delay gratification before turning around to look at the gift that the examiner was noisily wrapping was examined as an additional measure of executive function. For the children with typical development

in the Age match group, length of delay was significantly positively correlated with imitation in the exact condition of the path component ( $r = .39, p = .04$ ) and the goal component ( $r = .38, p = .05$ ). A similar pattern approached significance for the children in the Language match group. Length of delay was not related to imitation task performance for children with ASD.

*Imitation – Motor Imitation Scale (MIS)*

For the Motor Imitation Scales (MIS) measure, a composite score (i.e., Total Imitation) was calculated for the ASD group because the action and body tasks were significantly correlated with one another ( $r > .67, p < .001$ ). This Total Imitation score was also calculated for the Language match group ( $r > .38, p = .05$ ) and the Age match group ( $r > .48, p = .009$ ) as the action and body tasks were significantly correlated with one another in those groups as well.

The MIS Total Imitation composite score was correlated with imitation task performance and all correlations are reported in Table 7. Specifically, for the children with typical development in both the Language match and Age match groups, MIS Total score was significantly positively related to style imitation in the exact condition,  $r = .40, p = .04$  and  $r = .61, p = .001$ , respectively. For the children in the Language match and Age match groups, MIS Total score was also significantly positively correlated with goal imitation in the exact condition,  $r = .60, p = .38$  and  $r = .65, p = .001$ , respectively. Finally, the MIS Total score was significantly and positively correlated with path imitation in the exact condition for the children with ASD,  $r = .55, p = .004$ , and the children in the Language match group,  $r = .39, p = .04$ . Thus, overall imitation ability was related to style and goal imitation in the exact condition for both groups of children

with typical development whereas overall imitation ability was related to path imitation in the exact condition for the ASD and Language match groups.

#### *Determination of and Analyses with Covariates*

Correlations among composite measures of executive function tasks and the MIS with experimental imitation task performance are presented in Table 7. Due to the nature of these correlations, several measures were added to the previous analyses as covariates including A not B Correct composite, Gift Delay length of delay, and MIS Total Imitation score. The addition of each of these covariates did not have a significant impact on the previously reported findings. Specifically, there were no changes in main effects of diagnosis, main effects of imitation component, or the interaction between diagnosis and imitation component. Because no previously reported significant became non-significant and no previously non-significant differences became significant, the specific analyses are not reported here.

#### *Effect of ASD Symptoms and Intervention on Imitation Component Performance*

The bivariate correlations between imitation task performance (i.e., average style across both conditions, path goal difference score in choice imitation condition, path imitation in exact imitation condition, and goal imitation in exact imitation condition) and autism symptom severity (CARS2-ST) are presented in Table 8. Because both groups with typical development had a floor effect on the CARS2-ST, the CARS2-ST could not be analyzed for the groups with typical development in this same way. Additionally, correlations between imitation task performance and intervention/preschool intensity for the children with ASD are presented in Table 8.

The relation between ASD symptomatology severity, as measured by the CARS2-ST, and imitation task performance was examined within the ASD group. One significant positive correlation was found such that children with higher CARS2-ST scores, which is indicative of more severe ASD symptomatology, were more likely to show a preference for path rather than goal in the choice imitation condition,  $r(25) = .47, p = .02$ . See Figure 8 for a graphical illustration of this relation. The direction of this correlation was unexpected. CARS2-ST scores were not significantly related to matching style in the exact imitation condition,  $r(25) = .18, p = .40$ , or the choice imitation condition,  $r(25) = -.001, p = .99$ . Finally, CARS2-ST scores were not significantly related to matching path in the exact imitation condition,  $r(25) = .13, p = .54$ , or the goal in the exact imitation condition,  $r(25) = -.31, p = .14$ .

In order to further clarify the relation between ASD symptom severity and path/goal preference and to examine this relation in the children with typical development, a non-parametric Spearman's rho correlation was employed. The Spearman's rho correlation revealed a statistically significant correlation, such that having more severe symptoms of ASD was related to displaying a goal preference,  $r(66) = -.45, p < .001$ . See Figure 9 for a graphical illustration of this relation.

#### *Impact of Intensity of Intervention/Preschool Services*

The relation between imitation task performance and the intensity of preschool/intervention services for the ASD group was examined. Intensity of preschool and intervention services was calculated using a formula adapted from the Collaborative Programs of Excellence in Autism Research Network. For each preschool or intervention service the child received, the total length of time was calculated and then multiplied by

the number of hours of that service received. These services were then added together to result in an overall intensity value. Intensity of intervention was not significantly correlated with any of the performance measures within the experimental imitation task suggesting that imitation scores in participants with ASD were not due to intervention experiences. See Table 8 for these correlations.

## Discussion

In the past, most research on imitation in individuals with ASD has investigated the question of “do” individuals with ASD imitate rather than asking “how” do individuals with ASD imitate. The current study was uniquely able to examine both “do” young children with ASD imitate and “how” do they do it. Specifically, this study investigated whether preschoolers with ASD were able to imitate individual components of an action with an object in a manner similar to children with typical development matched on chronological age (Age match) and receptive language (Language match).

### *Imitation Task Performance Across Diagnostic Groups*

Overall, results indicated that preschool-aged children with ASD and typical development were able to imitate within the context of this play paradigm. In the exact imitation condition, children with ASD showed intact imitation skills. Specifically, children with ASD imitated both the examiner’s path (i.e., going up or down) and goal (i.e., putting the stuffed animal in or on a bowl) at the same rate as did children with typical development. This equivalent performance was true when children with ASD were matched to children with typical development who had the same receptive language ability and when matched to children with typical development who had the same chronological age. The performance of the children with typical development in this exact condition was very similar to the performance reported by children in Wagner et al.’s (2008) study, with high rates of style, path, and goal imitation when the imitation

was a straightforward replication of the model. Thus, the answer to the first question of “do children with ASD imitate?” is a clear “yes.”

This result fits with previous research that has found no differences in imitation with individuals with ASD, such as studies of goal emulation of actions on objects by Hamilton (2008). In the literature, it appears as though children (Stone et al., 1997) and adolescents (Rogers, Bennetto, McEvoy, & Pennington, 1996) with ASD show good imitation of actions when there is a clear goal or when actions are meaningful. Thus, in these conditions the performance of individuals with ASD may not be significantly different from the performance of comparison individuals. It may also be that imitation tasks that examine goal imitation or imitation of meaningful actions on objects is tapping into or using a coding strategy that fits with the yes/no question of “do they imitate (particular action or goal).”

With regard to the second question of “how” do children with ASD imitate, results indicated that children with ASD tend to focus more on the goal or outcome of another person’s behavior rather than on the process of that behavior. Specifically in the choice imitation condition, children with ASD were less likely to focus on the pathway that the examiner used to reach a goal and were also less likely to focus on the examiner’s style. Instead, children with ASD were more likely to focus on imitating the goal. By contrast, children with typical development maintained high rates of style imitation in this condition. As predicted by Wagner et al.’s (2008) findings and in contraction to the findings for the children with ASD in this study, children with typical development more frequently chose to preserve the path component at the expense of the goal component. Given how closely related the path and style components were in this

task, as they occurred together in space and time, the fact that less imitation of one these components co-occurred with less imitation of the other component is not surprising in the ASD group. Thus, the answer to the second question of “how do children with ASD imitate?” is that while they can imitate, there is something different about it. These findings may relate to the literature that suggest weaknesses in the abilities of individuals with ASD to imitate action style (Hobson & Hobson, 2008; Hobson & Lee, 1999) and body or facial movements that are “nonmeaningful” (Stone et al., 1997).

Examining the answers to the questions of “do” children with ASD imitate and “how” do they imitate within the context of this study can shed light on previously contradictory findings within the literature on imitation in ASD. Imitation, especially in this population, seems to be an extremely complex ability to understand. However, as evidenced in this study, it is possible for individuals with ASD to have both intact and impaired imitation skills. This contradiction seems to arise from the type of imitation skill being assessed as well as the level or method of assessment being employed.

Taken together, this suggests that one of the most impacted areas of an imitative act in individuals with ASD is the style or manner in which the action is performed. It is possible that this impairment in style imitation is a result of the incidental or implicit nature of this action within the context of the task. This suggestion fits with Hamilton’s (2008) hypothesis that children with ASD struggle with mimicry that involves kinematic features. This difficulty in style imitation in young children with ASD also fits squarely within Hobson and Hobson’s (2008) hypothesis and findings with adolescents with ASD, that this difficulty is specific to individuals with ASD even though they possess general imitative abilities in other areas.

Imitation impairments may become even more pronounced when task complexity increases. While complexity was not assessed in the current study, a bias toward imitating goal instead of path in the imitation choice condition suggests that differences are more pronounced when decision making is involved. Further, a focus on goal over path may result from a focus on the most recent or last action observed, which could be related to a narrow attentional focus. More research is needed to examine the impact of task complexity and attention on the issues of “how” do children with ASD imitate.

*Role of Executive Function, Overall Imitation Abilities, and ASD Symptom Severity*

The lack of group differences on the two measures of executive functioning (A not B and Gift Delay) that were employed in this study was not unexpected. While executive functioning difficulties have been found in older children and adults with ASD, these difficulties have not been found in younger children with ASD (Griffith et al., 1999; Dawson et al., 2002). Thus, the present study replicated previous findings that executive functioning skills are intact in preschool aged children with ASD. However, one potential alternative explanation for this finding is that the executive function tasks are appropriate for children between 6 and 22 months of age and the children in this study may have already gained these skills. That is, the tasks may have been too easy for the children in this study. Covariate analyses with these measures of executive functioning revealed that differences in imitation performance on the experimental task could not be explained by executive function performance. That is, any diagnostic group differences on imitation tasks were not due to underlying differences in executive function.

Although the experimental task did not find evidence for differences in imitation with objects in the exact choice condition, group differences were found on the Motor Imitation Scale. The finding that the ASD group differed from the two groups with

typical development on overall MIS score, was not unexpected, given that the MIS measures both actions with objects and imitation of body gestures. This is not surprising given the developmental pattern that imitation of body movements is more difficult than imitation of actions with objects (Stone et al., 1997). Significant correlations were present between the MIS Total score and specific components within the experimental imitation task. For the two groups of children with typical development, MIS performance was positively correlated with style and goal imitation in the exact imitation condition whereas for children with ASD and the Language matched children with typical development MIS performance was positively related to path imitation in the exact condition. However, these differences were not related to the differences observed in the experimental imitation task across diagnostic groups.

For the group of children with ASD, a curious relation between ASD symptom severity as measured by the CARS2-ST and experimental imitation task performance appeared. Contrary to expectations, children with more severe ASD symptomatology were more likely to show a more typical pattern of performance (path preference rather than a goal preference in the choice condition). However, examination of the pattern of this correlation revealed a possible outlier with one child with a high rating CARS2-ST rating showing a greater preference imitating path. When this potential outlier was removed, this correlation became a trend. Thus, without replication, it is difficult to know what to make with regard to this relation.

#### *Implications for Screening and Assessment of Individuals with ASD*

Imitation impairments are often viewed as one of the early “red flags” for ASD and are often assessed on early screening measures. However, the way that imitation skills are currently being assessed is either in a dichotomous way (i.e., does the child

imitate this action? Yes or no?) or as a conduit to assess creativity and flexibility in conceptualization (as on the ADOS-G).

Investigating subtle aspects in the development of imitation skills, as was done in this study, can inform the development of more sophisticated measures of imitation skills to address the clinical sense that a quality is missing. Although a child may be able to imitate after explicit teaching, they may not be learning a more sophisticated imitation skill (e.g., they may be learning the goal but not the style). Our current diagnostic protocols examine whether children can imitate (e.g., can they copy the examiner's actions with an object such as hopping a frog) but they do not examine how children imitate. Thus, the results of this study suggest that how we examine imitation impairments in our diagnostic assessments of ASD can be refined to reveal richer information regarding imitation abilities or impairments.

This current study suggests that for young children, there are more sophisticated ways to evaluate imitation by examining component parts as well as by paying attention to what children do or do not imitate. Given the developmental importance of imitation skills in social and language development, the more thorough the evaluation of the difficulties in imitation skills a child with ASD possesses, the more accurate and targeted interventions can be to address these skills. Thus, earlier intervention to address these specific imitation difficulties may result in earlier acquisition of important skills, which can have a positive impact on the development of social and language abilities.

#### *Implications for Interventions for Individuals with ASD*

Given the developmental theories of imitation in ASD, interventions that target the development of imitation skills early in development may have a significant impact on outcome. Not only is imitation an important skill in and of itself, but imitation also

provides an important tool for teaching other skills that may be impaired or delayed in children with ASD, such as language and play skills. Research has supported the relation between imitation and play skills in young children with ASD (Stone et al., 1997). In particular, pretend play skills tend to be impaired in individuals with ASD (APA, 2000) and may be targeted in early intervention curriculum. Pretend play skills can often be targeted through the use of imitation. However, often when young children are taught pretend play skills, their play can have a stilted feel to it. Given the findings of this research, this stilted feeling may be the result of a tendency to focus on goals (i.e., to feed the teddy bear bring the spoon to its mouth) without emphasis of the style or manner in which this play behavior is produced. Thus, it may be that play skills interventions would benefit from shifting focus to include these components of style in addition to attainment of goals to help foster a more fluid set of play skills to embrace “the spirit” of pretend play.

While individuals with ASD display or can learn the appropriate actions for social situations, it is often the way that they perform these actions that does not seem right to others and can get them in trouble socially. For example, a child with ASD may approach a peer and start a conversation. Yet, because the child with ASD is not making eye contact or nodding in response to the other child’s comments, this conversation may be quickly terminated by the peer who assumes that the child with ASD is not interested in what he is saying. Thus, employing an atypical style resulted in social rejection. As humans, we like to predict our environment as well as the people around us. Unfortunately, this tendency can result in snap judgments of others based on slight differences in something as seemingly insignificant as interpersonal style because it does not fit with what we typically predict or expect.

To date, there has been little focus on assessment of or intervention regarding imitation in older children and adults with ASD. However, given the types of social skills difficulties that individuals with ASD present with as older children, adolescents, and adults this seems to be a missing connection. While older individuals with ASD have often learned the right actions to employ in certain situations, they still run into social difficulties due to not using a fitting interpersonal style along with that action. Thus, they are not imitating or learning to use the appropriate social style. For interventionists, this style may seem naturally tied to the social action they are teaching, for the individual with ASD they are not picking up on this piece of information. Thus, this style component is the next step for therapists and individuals who work with individuals with ASD on effective social skills to consider explicitly elucidating and addressing in order to increase their chances of social success.

#### *Limitations and Future Directions*

While the current study's sample size was not large (i.e., 25 children in the ASD group), it is comparable to other studies that have investigated imitation in children with ASD and with typical development. Also, despite the current sample size, significant differences in performance were still found. However, future studies should include a larger sample of children. Replication of these findings with larger sample sizes will be instrumental in deepening the understanding and implications of these findings as well as their applicability. This is especially important given the mixed literature on imitation in ASD; often, small sample sizes can lead to a mixed literature when differences are subtle.

Future research studies should investigate the emergence of social communication skills and development of imitative abilities by component in children with ASD and typical development over time. The results of such a study would allow for comparison

of imitation ability, development of preference for certain components of an imitative action, and the influence of various social communication skills over time in children. This would help to identify which skills or abilities should be targeted in interventions for children with ASD. The longitudinal design would also allow for exploration of the developmental emergence of these different components of an imitative act. This pattern could then be compared with the emergence of these same abilities in children with typical development as well as other components of social communication.

Overall, the current study suggests that a more nuanced approach to evaluating imitation abilities in individuals with ASD reveals much more information about imitation performance. Thus, advancements in our assessment of imitation skills and interventions for or based upon imitation are possible, hopefully enhancing outcomes for individuals with ASD. Within the literature, these advancements may aid in the resolution of discrepancies surrounding imitation.

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## APPENDICES

Table 1. Demographics and Diagnostic Data

	ASD Group (n = 25)  <i>M</i> (SD)	Typical Group – Age Match (n = 29)  <i>M</i> (SD)	Typical Group – Language Match (n = 28)  <i>M</i> (SD)
Sex (Males: Females)	19: 6	20: 9	19: 9
Chronological Age (months)	43.48 (13.34)	43.79 (13.29)	37.75 (11.07)
Mullen Receptive Language raw score	31.36 (6.66)	36.52 (6.99)**	32.79 (6.06)
Mullen Receptive Language age equivalent	35.36 (10.59)	43.97 (11.97) **	37.71 (11.18)
Mullen Expressive Language age equivalent	33.52 (7.96)	44.03 (13.41) **	37.89 (12.08)
Mullen Visual Reception age equivalent	39.08 (13.80)	44.07 (13.90)	38.18 (11.10)
Mullen Fine Motor age equivalent	33.96 (12.08)	42.34 (13.75) *	35.89 (11.99)
Mullen Early Learning Composite	81.00 (17.76)	98.89 (10.44) **	97.29 (11.15) **
MIS – Body	11.08 (3.15)	13.97 (3.05)*	13.64 (3.02)*
MIS – Action	15.04 (1.46)	15.48 (1.46)	15.64 (1.03)
CARS2-ST	32.32 (1.61)	15.07 (.26) **	15.07 (.26) **
A not B % Correct	.88 (.15)	.94 (.10)	.89 (.13)
Gift Delay Length	40.40 (22.66)	46.24 (18.34)	44.57 (18.70)
Total Hours in Preschool	2133 (1308)	2477 (1319)	2030 (1063)

*Note: p-values indicate a statistically significant difference between the specific group with typical development and the ASD Group.*

\* $p < .05$

\*\* $p < .01$

Table 2. Sample Order of the Four Possible Combinations of Action Components Per Block

<b>Block</b>	<b>Trial</b>	<b>Style</b>	<b>Path</b>	<b>Goal</b>
1	1	Hop	Up	On bowl
	2	Hop	Down	In bowl
	3	Slide	Up	On bowl
	4	Slide	Down	In bowl

Table 3. Sample Administration Schedule

Session A*	Session 2	Session 3
ADOS	Warm-up (2 trials)	Warm-up (2 trials)
	Motor Imitation Scale	Straight ramp (exact – 4 trials)
	Wavy ramp (exact – 4 trials)	Mullen (Fine Motor)
	Mullen (Visual Reception)	Straight ramp (choice – 4 trials)
	Wavy ramp (choice – 4 trials)	Mullen (Expressive Language)
	Mullen (Receptive Language)	EF – Gift delay
	EF – A-not-B	Play session (for CARS2-ST scoring)

\* If ADOS has not been administered previously for the UA ASD Clinic or its research

Table 4. Imitation Task Performance Means and Standard Deviations for Groups and Conditions

Group	Straight <i>M</i> (SD)	Wavy <i>M</i> (SD)		
<b>ASD – Exact</b>			<i>t</i> (24)	<i>p</i> (2-tailed)
Style	.65 (.26)	.69 (.24)	-.72	.47
Path	.78 (.29)	.82 (.20)	-.78	.44
Goal	.78 (.30)	.78 (.26)	.00	1.00
<b>ASD – Choice</b>				
Style	.55 (.28)	.59 (.36)	-.48	.64
Path	.44 (.31)	.50 (.27)	-.92	.37
Goal	.61 (.35)	.59 (.31)	.28	.78
<b>Language match – Exact</b>			<i>t</i> (27)	
Style	.82 (.19)	.85 (.18)	-.62	.54
Path	.81 (.20)	.82 (.22)	-.17	.87
Goal	.77 (.24)	.82 (.23)	-.97	.34
<b>Language match – Choice</b>				
Style	.79 (.19)	.82 (.21)	-.85	.40
Path	.67 (.24)	.61 (.28)	1.00	.33
Goal	.28 (.18)	.33 (.31)	-.86	.40
<b>Age match – Exact</b>			<i>t</i> (28)	
Style	.87 (.18)	.90 (.16)	-.89	.38
Path	.84 (.19)	.84 (.19)	.00	1.00
Goal	.80 (.25)	.84 (.16)	-.84	.41
<b>Age match – Choice</b>				
Style	.78 (.21)	.84 (.21)	-1.78	.09
Path	.72 (.23)	.66 (.31)	.96	.35
Goal	.32 (.22)	.27 (.27)	.81	.42

Table 5. Mean Percentage of Imitation Components for Groups in Each Condition, *M*  
(*SD*)

	Style exact	Style choice	Path exact	Goal exact	Path/Goal Preference
ASD	.67 (.21)	.57 (.24)	.80 (.21)	.78 (.23)	-.13 (.48)
Language match	.83 (.15)	.80 (.17)	.82 (.16)	.79 (.19)	.33 (.34)
Age match	.87 (.15)	.84 (.18)	.84 (.16)	.81 (.18)	.43 (.34)

*Note: Positive scores reflect a path preference and negative scores reflect a goal preference.*

Table 6. Performance on Executive Function Tasks

Measure	Autism		Language Match			Age Match		
	<i>M</i>	SD	<i>M</i>	SD	<i>p</i>	<i>M</i>	SD	<i>p</i>
<b>A not B</b>								
% Correct	88.11	15.48	89.30	12.92	.759	93.87	10.07	.103
% wrong reversal trials	21.33	27.05	20.24	26.20	.882	10.34	22.01	.106
<b>Gift Delay</b>								
Delay (0-60 seconds)	40.40	22.66	44.57	18.70	.466	46.24	18.34	.300
Number of times peeked	2.12	1.39	2.18	1.52	.885	1.79	1.29	.376

*Note: p-values indicate a statistically significant difference between the specific group with typical development and the ASD Group.*

Table 7. Correlations for Covariate Variables,  $r(p)$

	Style exact	Style choice	Path exact	Goal exact	Path/goal preference choice
<b>A not B correct composite</b>					
ASD	.02 (.94)	-.07 (.73)	.30 (.14)	.27 (.19)	-.17 (.43)
Language match	.02 (.93)	.19 (.33)	.29 (.13)	.38* (.05)	.06 (.78)
Age match	.15 (.49)	.11 (.56)	.36 (.06)	.46* (.01)	.06 (.75)
<b>A not B error composite</b>					
ASD	.001 (.99)	.12 (.58)	-.12 (.57)	-.13 (.55)	.37 (.07)
Language match	-.03 (.90)	-.18 (.37)	-.29 (.13)	-.18 (.37)	-.29 (.14)
Age match	.08 (.70)	.04 (.85)	-.24 (.22)	-.11 (.57)	-.05 (.80)
<b>Gift Delay</b>					
ASD	-.07 (.75)	.14 (.50)	.11 (.59)	.26 (.21)	.10 (.63)
Language match	.18 (.35)	.21 (.29)	.33 (.08)	.35 (.07)	-.05 (.82)
Age match	.33 (.08)	.19 (.31)	.39* (.04)	.38* (.05)	-.05 (.81)
<b>MIS</b>					
ASD	.38 (.06)	.22 (.29)	.55** (.004)	.19 (.38)	.18 (.38)
Language match	.40* (.04)	-.07 (.72)	.39* (.04)	.60** (.001)	-.13 (.52)
Age match	.61** (.001)	.33 (.08)	.47 (.01)	.65** (.001)	.13 (.51)

\* $p < .05$

\*\* $p < .005$

Table 8. Correlation Between Task Performance, Symptom Severity, and Intervention in ASD Group,  $r$  ( $p$ )

	Style exact	Style choice	Path exact	Goal exact	Path/goal preference choice
CARS2-ST	.18 (.40)	-.001 (.99)	.13 (.54)	-.31 (.14)	.47* (.02)
Intervention/Preschool Intensity Total	.12 (.65)	-.04 (.90)	.12 (.65)	-.13 (.63)	.05 (.86)

\* $p < .05$

Figure 1.



Apparatus used in direct imitation condition from Wagner et al. (2008)

Figure 2.



Apparatus used for child and examiner in imitation choice condition from Wagner et al. (2008)

Figure 3.



Playset for child and examiner for 1 block (4 trials) of exact imitation with black ramp

Figure 4.



Playset for child and examiner for 1 block (4 trials) of exact imitation with wavy ramp

Figure 5.



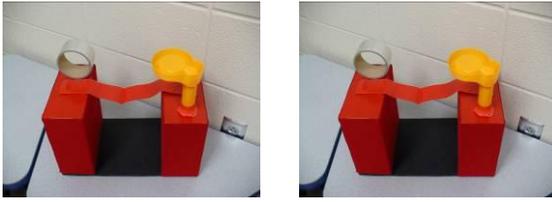
Playset for child and examiner for 1 block (4 trials) of choice imitation with black ramp

Figure 6.



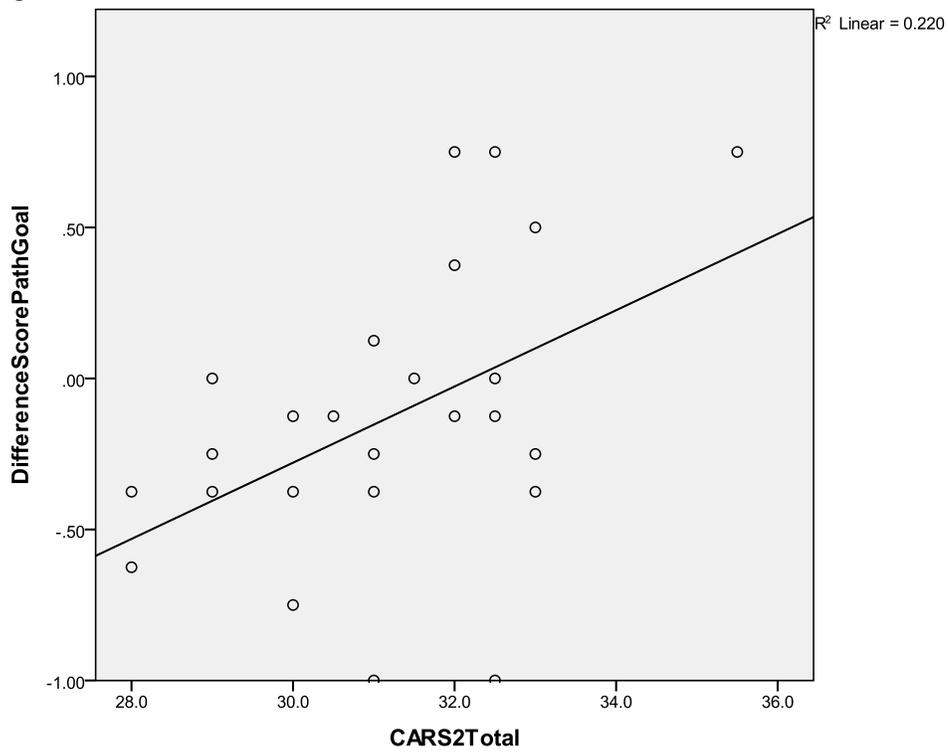
Playset for child and examiner for 1 block (4 trials) of choice imitation with wavy ramp

Figure 7.



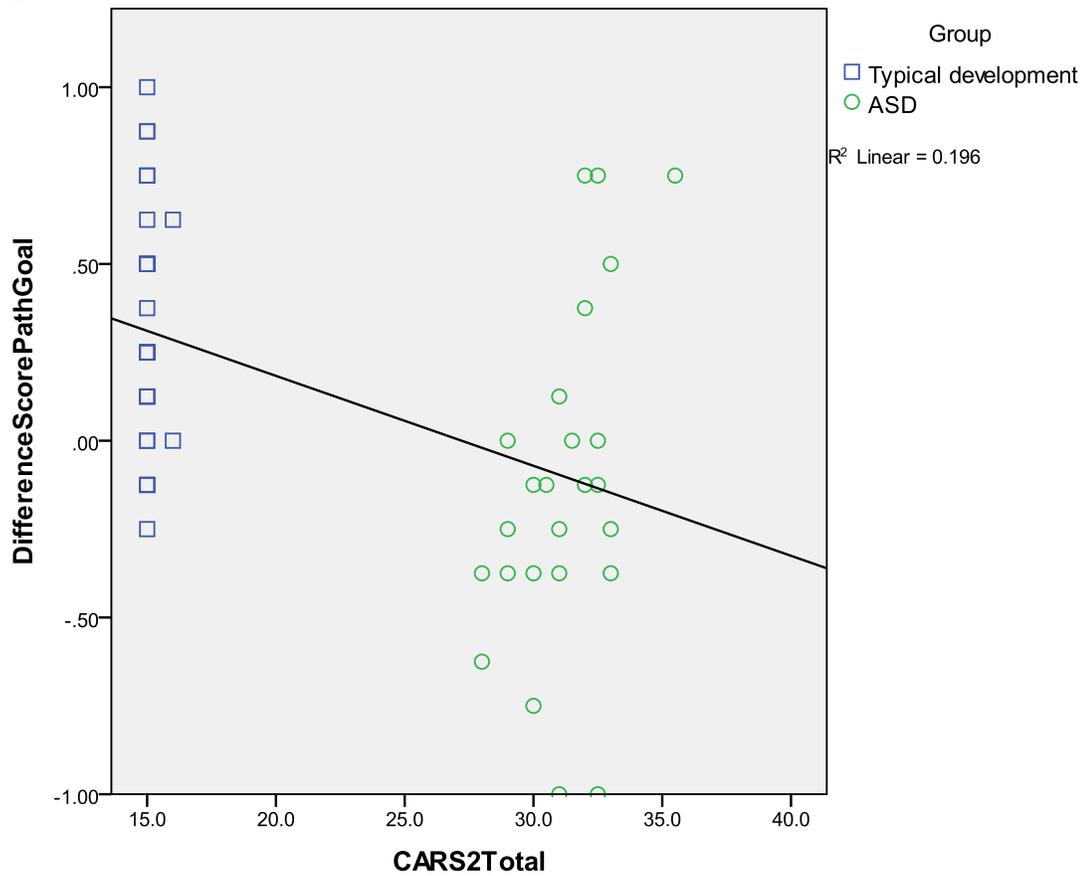
Warm-up bridge playset for child and examiner for 1 block (2 trials) of exact imitation

Figure 8.



Scatterplot of the relation between path or goal preference and CARS2-ST score ASD group

Figure 9.



Scatterplot of the relation between path or goal preference and CARS2-ST score for all participants