CONTINGENCY LEARNING IN PRESCHOOL-AGED CHILDREN WITH AUTISM SPECTRUM DISORDERS: AN EXAMINATION OF LEARNING SIMPLE AND COMPLEX RELATIONSHIPS

by

STEVIE NICHOLE FOWLER

A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Arts
in the Department of Psychology
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2011

ABSTRACT

Impairments in social interactions in children with Autism Spectrum Disorders (ASD) may be due to difficulties understanding the complex nature of social contingencies, as social information is not always straightforward or predictable. Prior research has shown that social interactions increase with greater predictability and that children with ASD are capable of learning contingent relationships and of modifying their behaviors based on these contingencies. The current study sought to explore contingency learning in children with ASD by examining learning of predictable relationships that varied in complexity. It was predicted that children with ASD would show deficits in contingency learning when the relationship was more complex. Fourteen preschoolers with ASD and twenty with typical development (TD) were included. Learning of simple and complex relationships was assessed using a contextual cueing task. In the simple condition, one picture in an array of four predicted the position of the target. In the complex condition, the arrangement of four stimuli was predictive of the target's location. Across conditions, there were unpredictable trials at the end of the task in which the relationship no longer applied. Contingency learning was measured using difference scores between latencies for predictable and unpredictable trials. Consistent with hypotheses, children with ASD exhibited learning in the simple condition. However, when presented with more complex relationships, differences in performance across predictable and unpredictable trials were negligible. Conversely, TD children did not show the expected pattern of learning across tasks. The pattern of results suggested that TD children showed learning of complex relationships as expected, but,

interestingly, did not exhibit overall learning of simple relationships. This is surprising as pilot research clearly documented contingency learning in children with typical development. Overall, these results suggest that preschool children with ASD may have impaired implicit learning of complex relationships but are able to learn simple relationships. Given the importance of early intervention, these results bolster the suggestion that preschool-aged children with ASD have the ability to learn contingent relationships, particularly when information is presented in a salient and simplified manner and may benefit from interventions that specifically teach contingency learning in both simple and complex relationships.

DEDICATION

This thesis is dedicated to all the loved ones who helped me and guided me through the trials and tribulations of creating this manuscript. In particular, to my most incredible mother, who in my lifetime has never waivered in her confidence in my abilities, even at times I questioned myself. To my father, who has always been my biggest fan. To all my friends and family, who provided never-ending support throughout this journey. I could not be more blessed.

LIST OF ABBREVIATIONS AND SYMBOLS

d	Cohen's *d*: Measure of effect size for use with *t*-tests or ANOVA
F	Fisher's *F* ratio: A ration of two variances
M	Mean: the sum of a set of measurements divided by the number of measurements in the set
η_p^2	Partial eta squared: Measure of effect size for use in ANOVA
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
$<$	Less than
$\leq$	Less than or equal to
$=$	Equal to

ACKNOWLEDGMENTS

I am pleased to have this opportunity to thank the many colleagues, friends, and faculty members who have helped me with this research project. In particular, Laura Klinger, the chairman of this thesis, for sharing her research expertise and wisdom regarding children with ASD. I would also like to thank all of my committee members, Mark Klinger, Ed Merrill, and Angie Barber for their invaluable input, inspiring questions, and support of both this thesis and my academic progress. I am most indebted to my fellow labmates and friends, Tia Holtzclaw and Megan Crisler, who dedicated endless hours of their precious time to helping me in the collection of my data and stood by my side throughout the completion of this manuscript. Also, thank you to my other labmates and research assistants for input and assistance in the development and completion of this project. This research would not have been possible without the support of my friends and fellow graduate students and of course of my family who never stopped encouraging me to persist.

Most importantly, I would like to say a special thank you to the children and families that participated in my research and the incredible preschool classrooms that I was so blessed to have worked with. Specifically, I would like to thank the incredible staff of Mitchell’s Place and their Executive Director, Sandy Naramore, who stood with me and personally introduced me to every family who walked through their doors. Also, to my other incredible recruitment sites, the University of Alabama Speech and Hearing Center and The Children’s Program, this research and continuing research would not be possible without the never-ending support you provide.

CONTENTS

ABSTRACT.. ii

DEDICATION... iv

LIST OF ABBREVIATIONS AND SYMBOLS v

ACKNOWLEDGMENTS vi

LIST OF TABLES.. viii

LIST OF FIGURES ix

1. INTRODUCTION 1

2. METHOD 11

a. Design 11

b. Participants...11

c. Apparatus 13

d. Measures 13

e. Procedure..17

3. RESULTS 19

4. DISCUSSION..25

REFERENCES 30

FOOTNOTES 33

LIST OF TABLES

Table 1: Participant Characteristics 34

Table 2: Predictable vs. Unpredictable Mean Reaction Times 35

LIST OF FIGURES

Figure 1: Example Stimulus Array 36

Figure 2: Overall Learning Effects by Task 37

Introduction

Autism Spectrum Disorders (ASD) refers to a continuum of disorders that are characterized by qualitative impairments in social and interpersonal interactions, deficits in communication skills, and restricted interests or repetitive behaviors, all of which vary in severity across the spectrum (American Psychiatric Association, 2000). The prevalence of ASD has continued to rise over the past decade with a recent estimate from the Center for Disease Control (2009) of 1 in 110 individuals, affecting males approximately 4 times more often than females. The symptoms of ASD can be detected in the early stages of development and tend to persist over the lifespan. However, it is believed that children with ASD who receive early intervention services tend to have much better prognoses than children who do not receive such services, marking the importance of continuing research exploring intervention strategies for young children with ASD.

One line of early intervention research seeks to understand the impairments in social interactions characteristic of ASD and to develop strategies to address these impairments. Klinger and Dawson (1992) suggest that to fully understand and effectively maneuver social interactions, one must have the ability to understand contingencies, meaning that an individual must understand that their actions affect others and others actions affect them in a similar manner. However, social contingencies are not always straightforward and predictable. Impairments in social interactions in children with ASD may be due to difficulties understanding the complex nature of social contingencies. The current study sought to explore contingency learning in children with ASD by examining learning of predictable relationships that varied in complexity. An examination of whether contingency learning difficulties are specific to social information and are present in both simple and complex stimuli, as well as the underlying cognitive mechanism of contingency learning will be discussed.

Contingency Learning in ASD

It is unclear whether individuals with ASD have a general impairment in contingency learning or whether this impairment is specific to understanding social information. While no study has directly assessed this issue, Dawson and colleagues (Dawson, Meltzoff, Osterling, Rinaldi, & Brown 1998; Dawson et al., 2004) have examined whether attention is differentially affected by social and nonsocial stimuli. As an initial study of the quality of response to social and nonsocial stimuli, Dawson, Meltzoff, Osterling, Rinaldi, and Brown (1998) examined visual orienting in a sample of young children with ASD, children with Down syndrome, and typically developing children. In this study, children were assessed on their responses (i.e., visual orientation toward the stimuli) to stimuli that were social in nature, including responding to a name call or attending to someone clapping their hands, and to nonsocial stimuli, including a playing jack-in-the-box or a shaking rattle. Overall, children with autism showed decreased responding to social and nonsocial stimuli when compared to the rest of the sample, with the most significant impairment noted when stimuli were considered social in nature. While these researchers suggested that children with autism exhibit general social orienting impairments, there was some concern expressed that the results could have been attributed to a differences in the familiarity of the stimuli and not truly reflective of differences in the social dimensions of the stimuli. In a follow-up study, Dawson et al. (2004) further explored the social orienting impairments in autism using an increased number of social and nonsocial stimuli that were selected based on similarity in their degree of familiarity. Consistent with the original findings, Dawson et al. (2004) reported that children with autism showed decreased responding across stimuli as compared to children with delayed development and typical development, with more severe impairments observed when presented with social stimuli. These studies support a theory of an overall impairment in attention toward social and nonsocial information with specific difficulties attending to social stimuli. It has been hypothesized that impairments with regards to social information may be due to the fact that social information is not always completely predictable or contingent (Dawson & Lewy, 1989).

In the first empirical study examining contingency learning in children with ASD, Ferrara & Hill (1980) examined the behaviors of children with ASD as they played with various toys under predictable and unpredictable conditions. Consistent with the suggestion that individuals with ASD have difficulties processing unpredictable information, the children showed disrupted behavior, including little attending to or manipulation of the toys, when the play condition was unpredictable. However, the same children showed increased interactions (e.g., looking at and manipulating the toys) when they were in predictable play conditions. Furthermore, the researchers found that not only did the children's responsiveness and interactions increase in the predictable situations, but they were also able to detect simple salient contingent relationships and develop appropriate expectations about their environment based on these relationships. More recently, Bhat, Galloway, and Landa (2010) examined associative learning in infant siblings of children with ASD and in low-risk infants. Using a highly predictable, simple learning task, these researchers showed comparable spontaneous associative learning of a nonsocial task across both groups, suggesting the benefit of presenting simple relationships in highly salient conditions. Further, they observed infants responses and attention to social and nonsocial stimuli.

Consistent with results from Ferrara and Hill (1980) that suggest that contingency learning is specific to social information, Bhat and colleagues (2010) showed increased social orienting to caregivers during the associative learning task in infants at risk for ASD when caregivers were responsible to initiating social engagement. However, these infants continued to attend to relevant, nonsocial stimuli and show associative learning in nonsocial conditions as well.

While little research has empirically tested whether children with ASD have impairments in contingency learning, there have been several studies showing that children with ASD show increases is social interaction when their social partner acts in a predictable, contingent fashion (Escalona, Field, Nadel, & Lundy, 2002; Heimann, Laberg, & Nordoen, 2006; Ingersoll & Schreibman, 2006; Klinger et al., 2009). Ingersoll and Schreibman (2006) used contingent imitation to increase participants' imitation skills and promote further social-communicative interactions, with results showing increases in imitative and spontaneous language, as well as pretend play. Similarly, two studies used imitative and contingent interactions to promote social interactions in children with autism (Escalona et al., 2002; Heimann, et al., 2006). These studies also showed increases in social-communicative behaviors, including looking, touching, and requesting or vocalizing. Furthermore, Klinger et al. (2009) have shown increases in turn-taking, requesting, and initiating joint attention in preschoolers with ASD using predictable imitation techniques. Although many studies have shown that increasing predictability and contingent imitation leads to increases in social interactions, the mechanism through which this occurs is not fully understood. Nadel et al. (2000) suggest that periods of intense imitation may make the social situation (or social contingency) more salient, leading to increased social-communicative responding. Further, Bhat et al. (2010) suggest that very young children with ASD may show increased contingency learning in highly salient conditions, and may benefit from being presented with relationship information in a more simple fashion, as past research has shown diminished performance in unpredictable and complex situations. These studies suggest that individuals with ASD are able to detect contingent relationships that are 100% predictable but have difficulty when the relationship in unpredictable.

Cognitive Processes Underlying Contingency Learning

Implicit learning offers one possible mechanism to explain the development of contingency learning. Implicit learning refers to a process that occurs without conscious awareness by which an individual acquires knowledge about their surrounding environment (Reber, 1989). According to Reber (1989), implicit learning skills are independent of age and intellectual functioning. This system is in place within the first year of life and is necessary for language learning and social understanding (Klinger, Klinger, & Pohlig, 2006). For example, children automatically learn the rules of grammar that govern their language long before those rules are explicitly taught, and children also learn to interpret and understand facial expressions without explicit teaching. Interestingly, children with ASD are characterized by impairments in language and social skills.

Klinger, Klinger, and Pohlig (2006) suggested that the implicit learning system is impaired in individuals with ASD. In order to compensate for these deficits, these individuals may rely on more explicit learning strategies, in which a conscious effort is made to learn. For example, these researchers showed that children with ASD showed decreased learning on implicit learning tasks that required visual interpretation of information across experiences (e.g., a prototype categorization task and an artificial grammar learning task). However, children who were characterized by strong explicit learning strategies tended to perform better on the implicit learning tasks than children who did not demonstrate a high level of these explicit learning strategies, as determined by their performance on the non-verbal matrix reasoning subtest of the Kauffman Brief Intelligence Test-2 (K-BIT2; Kaufman & Kaufman, 2004). They suggested that individuals with ASD who had high explicit reasoning were using these skills to compensate for impairments in implicit learning. This would suggest that increasing predictability would lead to a more explicit representation of a contingent relationship, meaning that learning is facilitated as the contingency is taught in a more explicit fashion.

Recent research has argued against this theory of impairment in the implicit learning system in individuals in ASD. Specifically, studies have argued that individuals with ASD show comparable implicit learning of spatial context using a visual search task (Barnes et al, 2008; Brown, Aczel, Jiminez, Kaufman, & Grant, 2010). However, one may argue that these contradicting findings are a result of enhanced explicit learning cues that are present in the contextual cueing task used in these studies. Specifically, the configuration of the stimuli in the task used was arranged such that there were systematic blank spaces that could have led to a more explicit representation of the relationship studied. Brown and colleagues (2010) also found evidence of intact implicit learning across other several measures. These researchers suggested that previous impairments in studies of implicit learning in individuals with ASD may be better accounted for by deficits in explicit learning abilities, which is in direct contrast to Klinger and colleagues. Thus, the research to date is contradictory with regards to implicit learning and more research is needed to identify whether implicit learning impairments exist.

In addition to possible cognitive impairments in implicit learning, it is well established that individuals with ASD have cognitive impairments in attention. Specifically, individuals with ASD may become fixated on objects or topics and have difficulties disengaging and redirecting their attention (Casey, Gordon, & Mannheim, 1993; Townsend, Harris, & Courchesne**,** 1996).

Thus, it is possible that impairments in contingency learning in complex situations are a result of difficulties in shifting attention and focusing on the important, relevant information. This would suggest that increasing the saliency of the relationship may help individuals with ASD focus their attention on the relevant information and therefore be able to attend to more complex contingencies (Dawson & Lewy, 1989; Dawson et al., 1998, 2004).

Contextual Cueing as a Measure of Contingency Learning

Implicit learning paradigms have been used to examine contingency learning abilities. Using a series of visual search tasks, Chun and Jiang (1998) utilized a contextual cueing task to examine implicit understanding of predictable relationships. They defined contextual cueing as a form of visual search facilitation that occurs with increased exposure to familiar stimuli configurations that occurs without conscious awareness. During contextual cueing tasks, participants are shown arrays of stimuli and are asked to locate a target stimulus (e.g., a rotated T) that is presented among distracter stimuli (e.g., rotated Ls). On half of the arrays, the location of the target can be predicted from the arrangement of the distracters, and on the other half of the arrays, the arrangement of the distracter stimuli are not predictive of the target's location. On these tasks, participants tend to show increased rates of responding to predictive trials as compared to unpredictable trials, but are unable to explicitly account for their performance. The contextual cueing task has been extensively studied with typically developing adolescents and adults (Chun, 2000; Chun & Jiang, 1998, 2003) and measures of implicit learning of spatial context, or contextual cueing, have also been used with adolescents and adults with ASD. Results from contextual cueing tasks with individuals with ASD have yielded equivocal findings, with some reporting impairments in contextual cueing in high-functioning adolescents and adults

(Klinger, Klinger, Travers, & Mussey, 2008) and others reporting comparable contextual cueing effects between individuals with ASD and typically developing peers (Brown et al., 2010).

Little research using the contextual cueing paradigm, however, has been conducted with children. In an original study of contextual cueing in children, Vaidya, Huger, Howard, & Howard (2007) compared performance on a visual search task presented by Chun & Jiang (1998) between a sample of typically developing elementary-aged children and a sample of young adults and concluded that implicit learning of spatial contextual information is not fully developed. While this initial evidence suggested reduced learning of spatial context in children, Dixon, Zelazo, & De Rosa (2010) argued that the task used by Vaidya et al. (2007) was too sophisticated for an elementary-aged sample. Dixon and colleagues sought to adapt the contextual cueing task to be developmentally appropriate and more engaging, and obtained results that contradicted the findings of Vaidya et al (2007). In this study, Dixon et al. (2010) reported a reliable contextual cueing effect for typically developing school-aged children, such that the children were able to implicitly learn the relationship between a target's location and repeated, predictive spatial contexts. In a recent study of contextual cueing in children with ASD, Barnes et al. (2008) reported no group differences in performance between children with ASD and their typically developing peers using the same task presented by Chun & Jiang (1998) and used by Vaidya et al. (2007).

Current Study

In a review of several early intervention studies of children with autism, Rogers (1996) reported that across all the studies, children receiving these early intervention services showed significant improvements in their development, including increases in IQ, language, and social skills and significantly decreased autism symptomatology. This review highlighted the importance of providing effective early intervention services. Prior research on impairments in social functioning in children with ASD has focused on teaching simple contingencies (Bhat et al., 2010; Ferrara & Hill, 1980; Ingersoll & Schreibman, 2006; Klinger & Dawson, 1992), and has shown that social interactions increase with greater predictability and that children with ASD are capable of learning these contingencies.

The purpose of the current study was to further explore contingency learning in children with ASD by focusing on increasing saliency and examining effects of relationship complexity. It was presumed that increasing the saliency of contingent relationships would help facilitate appropriately directed attention and promote a more explicit representation of the contingent relationship; in this way, learning was facilitated as the contingency was taught in a more explicit fashion. Additionally, as Baht, Galloway, and Landa (2010) suggested, it was assumed that children with ASD would show increased learning when relationship information was presented in an increasingly simple manner. Based on the prior literature documenting possible impairments in implicit learning and impairments in attention orienting, it was predicted that children with ASD would show deficits in contingency learning when the relationship was more complex. Learning, however, was expected to occur across tasks in children with typical development as they should not show similar impairments in implicit learning and attention orienting. In situations where the contingent relationship was simplified, the previous differences between groups were expected to diminish; it was expected that learning would be seen by both groups. Learning would likely occur more quickly in typically developing children as they are expected to use both implicit and explicit learning strategies, whereas children with ASD would be expected to use more explicit techniques. However, it was expected that children with ASD would match the typically developing children in maximizing performance; it could just take them longer due to a slower rate of learning. Overall, children with ASD were expected to show decreased contingency learning when the relationship was complex, but were expected to match the performance of typically developing children when the contingent relationship was simplified.

Method

Design

To examine learning under simple and complex conditions, this study used a 2 X 2 X 2 mixed factorial design. The design included two diagnostic groups (ASD vs. TD), two different types of trials (predictable vs. unpredictable), and two different test conditions (simple vs. complex). The test trials (predictable vs. unpredictable) and test conditions (simple vs. complex) were within-group manipulations, whereas the diagnostic group (ASD vs. TD) was a between-groups manipulation. Response time was used as the dependent variable in the model. The difference scores between reaction times for predictable and unpredictable trials were calculated to measure the overall learning effects.

Participants

Twenty-one children with ASD were recruited for this study. Fourteen of the recruited children with ASD completed the entire testing battery and were used in subsequent analyses. One child with ASD was excluded from data analysis due to losing too many test trials on the complex versions of the task in the data trimming process, two children were excluded due to significant cognitive delays and an inability to complete the contingency learning tasks, one child was excluded due to noncompliance in completing the second computer task, one was excluded due to failure to meet study diagnostic criteria for ASD, and two more children were excluded as they exceeded the maximum age range on the developmental assessment. The final sample of children with ASD were aged 35 months to 68 months (M = 51.00, SD = 10.71). Please refer to

Table 1 for demographic and descriptive information of the study sample. The children with ASD were recruited from the University of Alabama Autism Spectrum Disorders Clinic's research database and from local preschool classrooms for children with autism spectrum disorders. Families of children with ASD who received clinical services at the Autism Spectrum Disorders Clinic and indicated their willingness to be contacted regarding research opportunities were contacted by phone and asked if they would be interested in participating in the study. Parents of children attending local preschool classrooms responded to advertisements sent home via their child's classroom to indicate their willingness to participate in the study. Children with ASD were required to meet diagnostic standards for ASD using the Autism Diagnostic Observation Schedule – Generic (ADOS-G; Lord et al., 1989).

Twenty-five children with typical development were recruited for this study. Three children were excluded because they had a sibling with ASD, one child was unable to complete the second computer task, and one child left school before completing the second computer task. The final sample of twenty children with typical development ranged in age from 27 to 60 months (M = 47.00, SD = 8.87). These children were recruited through advertisements at local preschool classrooms. Children with typical development were recruited if they were within the chronological age range of the ASD participants and could potentially be matched to ASD participants using their raw score on the Receptive Language subtest of the Mullen Scales of Early Learning (Mullen, 1995). Typically developing children who endorsed any genetic disorders or developmental delays were excluded from the study to eliminate these potential similarities to children with ASD. Additionally, children with ASD who endorsed any co-occurring genetic diagnoses (e.g., Down syndrome and Fragile X) were not included in this study to avoid any potential diagnostic confounds.

To obtain a receptive language mental age and an estimate of developmental level, participants completed the Mullen Scales of Early Learning. Independent samples t-tests revealed that the ASD and TD groups were well matched on chronological age, $t(32) = -1.19$, $p = .12$, but significantly differed with regards to Receptive Language raw score, $t(32) = 4.54$, $p < .001$. While it was originally proposed to match participants on their Mullen Receptive Language subtest raw score, it was not possible to obtain a sample of preschool-aged children with ASD who matched typically developing peers on both chronological age and receptive language abilities due to the language delays characteristic of ASD. In order to minimize any potential confound of amount of life experience with contingency learning, participants were only matched on chronological age and any correlations between Receptive Language raw scores and developmental level with performance were considered in subsequent analyses. In retrospect, it should have been considered that preschool-aged children who have received a diagnosis of ASD are more likely to exhibit significant delays and less likely to be considered higher functioning; thus making a group match on chronological age and receptive language abilities in preschool-aged children difficult.

Apparatus

The experimental stimuli were presented using *Inquisit* 2.0 software and were run on a personal computer with an IBM compatible touchscreen monitor with a 12.1” diagonal display.

Measures

Mullen Scales of Early Learning (Mullen, 1995). The Mullen is composed of five scales that measure a child’s receptive and expressive language abilities, fine motor skills, visual-spatial skills, and gross motor abilities. This test can be used with children from birth to 68 months of age and has been used extensively in research with children with ASD. The Mullen was used to obtain a receptive language mental age for each participant in the study as well as get an estimate of their developmental level using the Early Learning Composite.

Autism Diagnostic Observation Schedule - Generic (ADOS-G; Lord, et al., 1989). The ADOS-G is a semi-structured play session that provides an assessment of communication, social interaction, and imaginative and symbolic play. The ADOS-G consists of four modules, from which an examiner can choose the most appropriate module for the individual based on their chronological age and expressive language level. Items are rated on a 0 – 2 point Likert scale, with higher scores indicating a greater severity of symptomatology. Scores on the ADOS-G are totaled to create an overall level of symptomatology that can be compared to cut-off scores for autism or another ASD. The ADOS-G has shown a fair correlation with the Autism Diagnostic Interview -Revised (ADI-R; Rutter, M., LeCouter, A., & Lord, C., 2002), a structured parent interview for the diagnosis of ASD. The ADOS-G was administered to children in the ASD group who had not previously had an ADOS completed at the Autism Spectrum Disorder's Clinic. ADOS-G scores were obtained from clinic records for children that had previously been administered the ADOS-G. Seven children completed Module 1 and six children were given Module 2 of the ADOS-G. Because ADOS-G modules do not provide comparable scores, in order to assess symptom severity, scores on the ADOS-G revised algorithms (Gotham et al., 2008) were computed and were then transformed using the ADOS calibrated severity metric (Gotham, Pickles, & Lord, 2009). This severity metric seeks to standardize ADOS scores across time of assessment, chronological age, and module to facilitate comparability of scores.

Contingency Learning Tasks. The following tasks were adapted from an unpublished Disney contextual cueing task that has been used with adolescents and adults (E. Merrill, personal communication, November 4, 2007; Klinger, Klinger, Travers, & Mussey, 2008).

Consistent with suggestion by Dixon et al. (2010), the current study sought to simplify this previously used task and develop an age-appropriate and engaging contextual cueing task for preschoolers. Two sets of stimuli that were considered interesting to preschoolers were selected, farm animals and vehicles, and the task was programmed with auditory animations to facilitate task engagement. Black and white drawings of farm animals and vehicles of similar shapes and sizes were selected and then each stimuli set was colored using similar color palettes using *Adobe Photoshop* software.

For task administration, the children sat in front of the touchscreen computer and the examiner was seated next to or just behind them. For each contingency learning task, the children were instructed to touch the appropriate cartoon object (i.e., a pig or a car) as quickly as possible when it appeared on the screen. Between trials, a fixation cross appeared in the middle of the screen so as to direct their attention back to the center and the experimenter instructed them to put their hands down. Once the children were attending to the task, the experimenter initiated the next trial. For each trial, after the children correctly touched the target stimulus, they would receive auditory feedback in the form of a pig oinking or car honking, after which the target stimulus disappeared and the fixation cross reappeared. The children were prompted as necessary to touch the pig (or car) as quickly as possible during a trial. If a child did not respond within 10 seconds on any trial, the examiner would hand-over-hand guide the child to the target stimulus.

To familiarize the children with the target stimulus, participants completed 3 teaching trials, in which only the target stimulus (i.e., a pig or a car) appeared in one of four outer quadrants on the screen. Then, in order to familiarize the children with having other stimuli in all the other quadrants on the screen, 3 teaching trials presented the target stimulus in one of the four outer quadrants and a similarly colored shape (e.g., oval) in all the other quadrants. The final three teaching trials were used to familiarize the children with all the task stimuli, so the target stimulus randomly appeared in one of the four outer quadrants while the other quadrants randomly displayed the other task stimuli. Once the children successfully completed nine familiarization trials, which were not used for analyses, the test trials began.

For the simple relationship contingency learning task, four objects of similar color and size (i.e., chicken, horse, cow, and rabbit when target was a pig; truck, plane, boat, and train when target was a car) were arranged in the center of the screen, one of which (the horse or the boat) was positioned such that it predicted the position of the target stimulus in the corresponding outer quadrant. Three more examples of the same stimuli were presented randomly in the outer quadrants on the screen, while the targeted cartoon object (i.e., a pig or a car) appeared in the quadrant predicted by the predictive stimulus in the center. See Figure 1 for an example stimuli array. The arrangement of the stimuli in the other three outer quadrants was randomized with every trial. The task consisted of 5 blocks with 12 trials per block and the time it took each child to touch the target stimulus was recorded for each trial. During the first 3 blocks, the location of the predictor stimulus in the center was 100% predictive of the location of the target in the corresponding outer quadrant. During the last two blocks, predictable and unpredictable trials were randomly intermixed such that 12 predictive trials were randomly presented among 12 trials in which the positioning of the stimuli were randomized and the familiar predictive stimulus was not predictive of the target's location.

Similarly, in the complex condition, four objects of similar color and size were arranged meaningfully in the center of the screen. However, in the complex condition, the arrangement of all four stimuli in the center quadrants was predictive of the outer quadrant in which the target stimulus appeared. Again, distracter stimuli in the other three outer quadrants were presented randomly with every trial. This task also consisted of a block of 9 teaching and familiarization trials and 5 test blocks with 12 trials per block and each child's reaction time was recorded on every trial. During the first 3 blocks, the arrangement of all four stimuli in the center was 100% predictive of the location of the target in the outer quadrants. During the last two blocks, predictable and unpredictable trials were randomly intermixed such that 12 predictive trials were randomly presented among 12 trials in which the configuration of the stimuli in the center were not predictive of the target's location.

In order to make the predictive relationship between the stimuli in the center quadrants and the location of the target more salient, the four stimuli in the center quadrants were displayed for one second prior to the appearance of the distracter stimuli and the target stimulus in the outer quadrants. This sought to direct the children's attention to the stimuli in the center of the screen and make the importance of attending to the center stimuli more apparent. The two separate conditions that varied the complexity of the contingent relationship were administered during separate sessions and each took approximately 15 – 20 minutes to complete. The order of presentation of these tasks was counterbalanced across groups.

Procedure

The testing procedures took place in the children's preschool centers or at the University of Alabama Autism Spectrum Disorders Clinic at the Child Development Research Center (CDRC). Generally, the testing occurred across two sessions that were both conducted within two weeks of each other. Before any testing began, the parent(s) signed a consent form that explained the purpose of the testing, the possible risk(s) associated with the testing, and that they or their child could decline further participation at any time. Parents and their children were told that the purpose of the testing is to see how quickly their child can touch a cartoon object (i.e., a pig or a car) when it appears on the computer screen. After consent was obtained, each parent was asked to complete a demographics questionnaire. Each child was tested in a private room where the contingency learning tasks were administered.

During the first session, the children completed the first condition of the task and the Mullen was administered, which generally took a total of 45 minutes to an hour to complete. At the second session, the children completed the second condition of the task and any remaining subtests from the Mullen. If the ASD participants had not completed an ADOS-G previously with the Autism Spectrum Disorders Clinic, they were given one during a subsequent session, which generally took 35 – 40 minutes to complete. Both sessions took approximately 1½ hours if an ADOS-G was previously completed or approximately 2 hours if the administration of an ADOS-G was necessary. All parents received a brief report describing their child’s performance on the standardized testing, and all the children received stickers after completing each block of trials in the contingency learning task and at the end of each session.

Results

A one-tailed alpha of .05 was considered statistically significant for all of the following analyses. Reaction times were collected and the differences between mean reaction times on predictable and unpredictable trials during the last two intermixed blocks were used to measure overall learning. Prior to analyses, reaction times below 500 ms and above 10,000 ms were trimmed as reaction times of less than 500 ms were considered too fast to have actually perceived the stimuli and respond to them and children received hand-over-hand guidance after 10,000 ms of non-responding. After the trimming process, children with ASD lost an average of .43 predictable test trials, with a range of 0 – 3 trials trimmed, and an average of .29 unpredictable test trials, with a range of 0 – 2 trials trimmed, within the simple condition. In the complex condition, an average of .29 (range 0 – 2) predictable trials and .21 (range 0 – 2) unpredictable trials were trimmed. For children with typical development, an average of .05 (range 0 – 1) predictable trials and .25 (range 0 – 2) unpredictable trials were trimmed within the simple condition and an average of 0 (range 0) predictable trials and .4 (range 0 – 3) unpredictable trials were trimmed within the complex condition.

As is common when measuring reaction times in preschoolers, there was a significant amount of variability in the data. A variety of strategies for data analysis were considered, including looking at raw mean latencies, median latencies, reciprocal mean latencies, and trimming each individuals data based on a distribution of their own reaction times. Considerations of trimming each individual's data yielded concerns about losing test trials, particularly the longer unpredictable reaction times, which could significantly change pattern of results given the small number of test trials. The use of median latencies was also considered, but yielded concerns that due to the small number of test trials, medians would not be stable enough to significantly help address variability concerns. Transforming the data by using the reciprocal mean latencies was considered the most effective option for addressing variability concerns with raw mean latencies, as taking the reciprocals of the latencies would help reduce variability by making the distribution more normal without eliminating any test trials.

Mean reciprocal latencies (1/latency) were computed using the mean of the 12 predictable and the mean of the 12 unpredictable trials in the last two blocks. In order to obtain meaningful reaction times, these latencies were then retransformed by again taking the reciprocal of the transformed mean latencies for predictable and unpredictable trials. The difference scores between these means were used as the measure of overall learning for each task. Given the significant difference in receptive language scores between diagnostic groups, Pearson correlations between overall learning performance in each task and Receptive Language raw scores on the Mullen were computed across and within diagnostic groups. These analyses revealed no significant correlations between performance on either simple or complex tasks across diagnostic groups, $r(34) = -.20$, $p = .13$ and $r(34) = .06$, $p = .36$, respectively. Similarly, no significant correlations between simple and complex task performance and Receptive Language raw score were found within diagnostic groups, with Pearson correlations for children with typical development of $r(20) = -.15$, $p = .27$ and $r(20) = -.11$, $p = .33$, respectively, and correlations for children with ASD of $r(14) = .08$, $p = .39$ and $r(14) = -.05$, $p = .43$, respectively. Additionally, no significant correlations were found between chronological age and task performance both across and within diagnostic groups. Given the lack of correlations between receptive language scores and overall task performance and the study's small sample size, the following models did not include receptive language as a covariate.

An examination of the transformed mean reciprocal latencies of predictable and unpredictable trials provided an initial opportunity to explore the general prediction that both groups would show learning of simple relationships, but would differ in performance when a relationship's complexity increased. The means and standard deviations both across groups and separated by diagnostic group are presented for each task variation in Table 2. There appeared to be overall learning effects for both simple and complex conditions when examined across groups. Specifically, there appeared to be an approximately 68 ms overall learning effect in the simple condition and a 75 ms learning effect in the complex conditions, such that participants were responding faster to predictive versus non-predictive trials. When diagnostic status was taken into consideration, children with typical development continued to show a positive learning effect of 125 ms in the complex condition, but only a 23 ms effect for the simple condition. Initial examination of learning effects in the ASD group seemed to provide evidence consistent with original prediction. Under conditions of learning simple relationships, children with ASD exhibited a large overall learning effect of approximately 133 ms, but showed negligible learning in the complex condition, with only a 5 ms difference in responding to predictive and non-predictive trials. While the differences in these latencies generally appeared to be trending toward prediction, there was a significant amount of variability present in the data.

To test if there was a statistically significant diagnostic reaction time difference across task conditions, a 2 (simple vs. complex) X 2 (predictable vs. unpredictable) X 2 (ASD vs. TD) mixed factors ANOVA was conducted, with predictability and relationship complexity introduced as within-subjects variables and diagnostic status as a between-groups manipulation[1].

In this model, the transformed reciprocal mean latencies for predictable trials were compared to the transformed reciprocal mean latencies for unpredictable trials from the last two blocks from both the simple and the complex relationship task variations. The 2 X 2 X 2 ANOVA revealed a significant main effect of predictability with a medium to large effect size, $F(1,32) = 4.28$, $p = .02$, $\eta_p^2 = .12$, such that participants were responding more quickly to predictable than unpredictable trials overall. There was also a significant task variation by predictability by diagnosis interaction, $F(1,32) = 6.14$, $p = .01$, $\eta_p^2 = .16$, such that there was a significant effect of predictability by task variation that changes across diagnostic groups. The effect size estimate is would be considered large and substantiates this finding. See Figure 2. There were no significant main effects of task variation or diagnosis ($F \leq 1$). Similarly, there were no significant two-way interactions of task by diagnosis, predictability by diagnosis, or predictability by task variation, all with $F < 1$.

Follow-up 2 X 2 ANOVAs with predictability as a within-subjects factor and diagnostic status as a between-subjects factor were conducted for each task variation. Within the simple condition, the 2 (predictable vs. unpredictable) X 2 (ASD vs. TD) ANOVA revealed a significant main effect of predictability, $F(1,32) = 4.38$, $p = .02$, $\eta_p^2 = .12$ and no significant effects of diagnosis, $F(1,32) = .07$, $p = .40$, $\eta_p^2 = .002$, or predictability by diagnosis, $F(1,32) = 2.18$, $p = .08$, $\eta_p^2 = .06$, such that both groups are showing significantly faster reaction times to predictable vs. unpredictable trials when the contingent relationship is simple. However, when the contingent relationship is complex, the same 2 X 2 ANOVA does not reveal any significant main effects of predictability or diagnosis, $F(1,32) = 1.74$, $p = .10$, $\eta_p^2 = .05$ and $F(1,32) = .44$,

p = .26, η_p^2 = .01, respectively, nor a predictability by diagnosis interaction, $F(1,32) = 1.48$, p = .12, η_p^2 = .04.

Due to the small sample size and the significant amount of variability in the data, one-sample t-tests were conducted to further explore overall learning effects within each task variation and diagnostic group. The following analyses used difference scores between the mean of predictable and unpredictable trials in the last two blocks of the task and sought to examine if these scores significant differed from 0. A one-sample t-test of overall learning effects in the simple condition revealed a significant effect of predictability across diagnoses, $t(33) = 1.83$, $p = .04$, $d = .31$, with a small effect size. This effect drops in significance and effect size for children with typical development, $t(19) = .55$, $p = .29$, $d = .12$, suggesting that children with TD are not learning the simple relationship as expected. However, the overall learning effect stays significant for children with ASD, $t(13) = 2.00$, $p = .03$, $d = .53$, suggesting that predictability is helping children with ASD learn the simple relationship and is supported by a medium effect size. A one-sample t-test of overall learning effects in the complex condition reveals an approaching significant effect of predictability across diagnoses, $t(33) = 1.55$, $p = .07$, $d = .27$. Unlike performance in the simple condition, children with typical development showed a significant overall learning effect in the complex condition, $t(19) = 1.848$, $p = .04$, $d = .41$. Children with ASD, however, did not show significant learning effects in the complex condition, $t(13) = .074$, $p = .47$, $d = .02$, with a very small effect size.

Finally, correlation analyses were conducted to explore the relationship between ASD symptom severity and overall learning effects for simple and complex conditions. ADOS-G scores as obtained from the revised algorithms (Gotham et al., 2008) were standardized using the calibrated severity metric presented by Gotham, Pickles, & Lord (2009). Using the child's chronological age at time of ADOS-G administration and the ADOS-G module administered, raw scores can be converted to an overall severity score that can then be used for comparisons across the entire ASD sample. These analyses revealed no significant correlations between performance on either simple or complex tasks and ASD symptom severity, with $r(13) = .04$, $p = .45$ and $r(13) = -.04$, $p = .45$, respectively.

The pattern of data suggests that, contrary to prediction, the overall effect of predictability for children with TD is being carried by overall learning in the complex condition, as children with TD did not show significant effects for overall learning in the simple condition[2]. However, consistent with prediction, children with ASD are showing significant overall learning effects of simple relationships and not showing learning under the complex condition. Receptive language level, chronological age, and ASD symptom severity were not related to overall learning effects in this study.

Discussion

Several intervention studies have documented that individuals with ASD show increased social and communicative skills when information is presented in a predictive pattern and in highly salient conditions (Escalona, Field, Nadel, & Lundy, 2002; Heimann, Laberg, & Nordoen, 2006; Ingersoll & Schreibman, 2006; Klinger et al., 2009). Despite these findings from intervention research, few studies have examined contingency learning in individuals with ASD. Results of the intervention studies suggest that children with ASD are able to detect perfect or simple contingencies. However, whether individuals with ASD have impairments in the ability to detect non-perfect or complex contingencies has not been studied. The current study sought to further explore contingency learning in preschoolers with ASD by presenting information in a more salient manner and varying the level of relationship complexity. Consistent with previous literature, it was proposed that children with ASD would show learning of simple relationships that are presented in a salient manner but would show diminished performance in learning a contingent complex relationship. Overall learning and performance for children with ASD were compared to similarly aged preschoolers with typical development. It was assumed that children with typical development would show learning across both tasks, as they are able to rely on both implicit and explicit learning mechanisms.

Consistent with prediction, in the present study children with ASD exhibited a pattern of learning in the simple condition. However, when presented with more complex relationships, differences in performance across predictable and unpredictable trials were negligible. On the other hand, children with typical development did not show the expected pattern of learning across tasks. Specifically, children with typical development showed learning of complex relationships as expected, but, interestingly, did not exhibit statistically significant differences in reaction times across predictable and unpredictable trials in the simple condition. While this pattern was unexpected, an examination of the pattern of means reveals that children with typical development showed a trend of learning that was consistent with prediction. During the task piloting process, children with typical development showed greater overall learning within the simple condition than reported in the current study. It is possible that the small sample size and the great amount of variability in this study have washed out effects in the tests of significance.

In the current study, children with ASD showed patterns of learning suggesting impairments in the ability to learn complex relationships and may also provide further evidence toward the theory of impairments in implicit learning. Specifically, children with ASD exhibited intact ability to learn highly salient, simple relationships that are 100% contingent and showed difficulty learning complex relationships. The impairments in learning the complex information on this contextual cueing task in children with ASD are in contrast to recent research suggesting intact implicit learning abilities in this population (Barnes et al., 2008; Brown et al., 2010). Both of these previous studies used the contextual cueing task presented by Chun & Jiang (1998) in an elementary-aged sample of children and it is possible that the differences in the results between these studies and the current research are a product of differences in the task. Specifically, in the original contextual cueing task, the stimuli are arranged in such a way that there are blank spaces in the stimulus array. It is possible that this type of display would lead to more explicit cues as to the location of the target stimulus.

As described, the task used in the current study was developed to be more engaging and developmentally appropriate for preschoolers. In this task, the stimuli were arranged in such a way that stimuli were displayed in all quadrants across all the arrays. It is possible that the arrays in the current task could be considered to have led to fewer explicit cues, and therefore better assessed implicit learning. If this is so, then the current results would provide further evidence towards a theory of impairments in implicit learning. While the current data falls in line with past research documenting impairments in implicit learning, it cannot be definitively concluded that children with ASD could not learn the information presented in the complex condition if given more exposure to the relationships. In the current programming of the task, the children with ASD were exposed to each complex relationship a total of 9 times during the acquisition trials and 3 times during the test trials. It is possible that children with ASD may be capable of learning these complex relationships, but are slower or less efficient than their typically developing peers. Therefore, it is possible that children with ASD may be able to learn these relationships with increased exposure, even though they did not show learning of complex relationships on the current task.

The pattern of results from this study suggests that the current task has benefit, but is marked by several limitations. First, a small sample size may not be conducive to finding the predicted effects particularly because the effect sizes ranged from small to larger and there was a great deal of variability in reaction time in this sample. Recruitment of a much larger sample size as well as increasing the number of test trials could address some of these issues. However, one needs to consider that reaction time research in preschoolers is particularly messy, and while increasing the number of test trials would be expected to help bolster the data, it is not likely to be a practical solution. In the current study, the children completed 69 trials – 9 familiarity trials, 36 learning trials and 24 test trials – which took 15 to 20 minutes of sustained attention to complete. Increasing the length of the task may introduce such problems as fatigue effects during test trials and difficulty maintaining attention to task demands in order to provide optimal performance across an extended period of time.

In his review of various preschool attention tasks, Mahone (2005) discusses difficulties associated with measuring mean reaction times in a preschool sample. However, it was noted that the preschool reaction time tests reviewed also included a measure of accuracy in addition to a measure of response latency. The current task was a forced choice task, in which the target stimuli stayed on the screen until the correct response was given, and was not programmed to record any potential incorrect responses. In retrospect, it would have been helpful to include response accuracy was well as reaction time. By adding a measure of accuracy, we would be able to further explore the nature and validity of the reaction times obtained during the task. Including accuracy rates could help control for some of the variability, as trade-off effects between response accuracy and response latency could be further separated and examined. Also, analysis of accuracy during acquisition trials would provide the opportunity to explore the extent to which children learned the relationships. Specifically, it could be examined whether low accuracy during acquisition led to creating incorrect associations and whether learning was enhanced in children who exhibited high accuracy during acquisition as they may have developed a stronger relationship between the central configuration and the response. Further, adding eye tracking to the current study could also be helpful in exploring effects of the pattern of visual search. Alternatively, contingency learning could be studied using a different paradigm that is less influenced by attention.

Overall, children with ASD showed learning patterns that were consistent with previous literature suggesting impairments in the ability to learn complex relationships. This impairment was found even in the current nonsocial task. Given the importance of early intervention, these results bolster the suggestion that preschool-aged children on the spectrum have the ability to learn contingent relationships, particularly when information is presented in a salient and simplified manner. However, preschool children with ASD may struggle with less simple complex relationships as is typical of social relationships. These results suggest that preschool children with ASD may benefit from interventions that specifically teach contingency learning in both simple and complex relationships.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders.* (4th ed., text revision). Washington, DC: Author.

Barnes, K. A., Howard, J. H., Howard, D. V., Gilotty, L., Kenworthy, L., Gaillard, W. D., & Vaidya, C. J. (2008). Intact implicit learning of spatial context and temporal sequences in childhood Autism Spectrum Disorders. *Neuropsychology, 22*, 563-570.

Bhat, A. N., Galloway, J. C., & Landa, R. J. (2010). Social and non-social visual attention patterns and associative learning in infants at risk for autism. *Journal of Child Psychology and Psychiatry, 51,* 989-997.

Brown, J., Aczel, B., Jiminez, L., Kaufman, S. B., & Grant, K. P. (2010). Intact implicit learning in autism spectrum conditions. *The Quarterly Journal of Experimental Psychology, 63,* 1789-1812.

Casey, B. J., Gordon, C. T., & Mannheim, G. B. (1993). Dysfunctional attention in autistic savants. *Journal of Clinical and Experimental Neuropsychology, 15,* 933-946.

Centers for Disease Control and Prevention. (2009, December). Prevalence of autism spectrum disorders—Autism and Developmental Disabilities Monitoring Network, United States, 2006. Retrieved October 25, 2010, from http://www.cdc.gov/mmwr/pdf/ss/ss5810.pdf.

Chun, M. M. (2000). Contextual cueing of visual attention. *Trends in Cognitive Science, 4*, 170-178.

Chun, M. M. & Jiang, Y. (1998). Contextual cueing: Implicit learning and memory of visual context guides spatial attention. *Cognitive Psychology, 36*, 28-71.

Chun, M. M. & Jiang, Y. (2003). Implicit, long term spatial contextual memory. *Journal of Experimental Psychology: Learning, Memory and Cognition, 29,* 224-234.

Dawson, G., & Lewy, A. (1989). Arousal, attention, and the socio-emotional impairments of individuals with autism. In G. Dawson (Ed.)*, Autism: Perspectives on nature, diagnosis, and treatment.* New York: Plenum, 49-74.

Dawson, G., Meltzoff, A., Osterling, J., Rinaldi, J., & Brown, E. (1998). Children with autism fail to orient to naturally occurring social stimuli. *Journal of Autism and Developmental Disorders, 28*, 479-485.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: Social orienting, joint attention, and attention to distress. *Developmental Psychology, 40*, 271-283.

Dixon, M. L., Zelazo, P. D., & De Rosa, E. (2010). Evidence for intact memory-guided attention in school-aged children. *Developmental Science, 13*, 161-169.

Escalona, A., Field, T., Nadel, J., & Lundy, B. (2002). Brief report: Imitation effects on children with autism, *Journal of Autism and Developmental Disorders, 32,* 141-144.

Ferrara, C., & Hill, S. D. (1980). The responsiveness of autistic children to the predictability of social and nonsocial toys. *Journal of Autism and Developmental Disorders, 10,* 51-57.

Gotham, K., Pickles, A., & Lord, C. (2009). Standardizing ADOS scores for a measure of severity in Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 39,* 693-705.

Gotham, K., Risi, S., Dawson, G., Tager-Flusberg, H., Joseph, R., Carter, A., …Lord, C. (2008). A replication of the Autism Diagnostic Observation Schedule (ADOS) revised algorithms. *Journal of the American Academy of Child and Adolescent Psychiatry, 47,* 642-651.

Heimann, M., Laberg, K. E., & Nordoen, B. (2006). Imitative interaction increases social interest and elicited imitation in non-verbal children with autism. *Infant and Child Development, 15,* 297-309.

Ingersoll, B., & Schreibman, L. (2006). Teaching reciprocal imitation skills to young children with autism using a naturalistic behavioral approach: Effects on language, pretend play, and joint attention. *Journal of Autism and Developmental Disorders, 36,* 487-505.

Kaufman, A. S. and Kaufman, N. L. (2004). *Kaufman Brief Intelligence Test, 2nd Ed. (K-BIT2)*. Circle Pines, MN: American Guidance Service.

Klinger, L. G., & Dawson, G. (1992). Facilitating early social and communicative development in children with autism. In S. F. Warren and J. E. Reichle (Eds.), *Causes and effects in communication and language intervention.* England: Paul H. Brookes Publishing, 157-186.

Klinger, L. G., Griffith, E. M., Mussey, J. L., Williams, A., Noble, H., Perez, T., McCurry, S., & Holtzclaw, T. (2009). Preschool social skills intervention for children with autism spectrum disorders: A child-directed approach. Manuscript in preparation.

Klinger, L. G., Klinger, M. R., & Pohlig, R. L. (2006). Implicit learning impairments in autism spectrum disorders: Implications for treatment. In J. M. Perez, P. M. Gonzalez, M. L. Comi, & C. Nieto (Eds.), *New developments in autism: The future is today*. London: Jessica Kingsley Publishers, 76-103.

Klinger, M. R., Klinger, L. G., Travers, B. G., & Mussey, J. L. (2008). *Contextual learning in high-functioning persons with ASD.* Poster presented at the International Meeting for Autism Research, London, May 15-17.

Lord, C., Rutter, M., Goode, S., Heemsbergen, J., Jordan, H., Mawhood, L., Schopler, E. (1989). Autism diagnostic observation schedule: a standardized observation of communicative and social behavior, *Journal of Autism and Developmental Disorders, 19,* 185-212.

Mahone, E. M. (2005) Measurement of attention and related functions in the preschool child. *Mental Retardation and Developmental Disabilities Research Reviews, 11,* 216-225.

Mullen, E. M. (1995). *Mullen Scales of Early Learning*. American Guidance Services, Inc. Circle Pines, MN.

Nadel, J., Croue, S., Mattlinger, M. J., Canet, P., Leaple, H., Leaple, L., & Martini, M. (2000). Do children with autism have expectancies about the social behaviour of unfamiliar people? A pilot study using the still-face paradigm. *Autism, 4,* 133–145.

Reber, A. S. (1989). Implicit learning and tactic knowledge. *Journal of Experimental Psychology, 118,* 219-235.

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

Rutter, M., LeCouteur, A., & Lord, C. (2002). *Autism Diagnostic Interview-Revised: A comprehensive interview to aid in diagnosis and treatment of autism spectrum disorders*. Los Angeles, CA: Western Psychological Services.

Townsend, J., Harris, N. S., & Courchesne**,** E. (1996). Visual attention abnormalities in autism: Delayed orienting to location. *Journal of the International Neuropsychological Society, 2,* 541-550.

Vaidya, C. J., Huger, M., Howard, D. V., & Howard, J. H. (2007). Developmental differences in implicit learning of spatial context. *Neuropsychology, 21,* 497-506.

Footnotes

[1]Two variations of task stimuli were used and the order of presentation was counterbalanced across participants. Effects of task stimuli presentation were examined by adding stimuli set (farm animals vs. vehicles) into the model as a between subjects factor. When stimuli set was introduced into the overall model, there was no change in the pattern of results. Given its lack of influence on the pattern of results and the study's small sample size, stimuli set was not maintained as a between subjects variable in the final 2 x 2 x2 model or subsequent analyses.

[2]Given the surprising results on simple task within the typical group, we completed subsequent analyses to test the notion that typical children may have become consciously aware of the predictable relationship during acquisition trials and quit using this learned relationship during test trials when they encountered arrays in which the relationship no longer applied. To test this idea, we looked at mean reaction times for the 12 predictable trials in the last acquisition block and 12 predictable test trials and found negligible differences in response latencies across tasks and across diagnostic group. These analyses did not support the current explanation for the pattern of results for children with typical development.

Table 1

Mean and (Standard Deviation) of Participant Characteristics and Significance Levels of T-test Comparing the Groups (p)

	TD	ASD	*P*
N	20	14	
Chronological Age (mo)	47 (8.87)	51.00 (10.71)	.12
Mullen			
Receptive Language	39.75 (5.73)	31.71 (3.93)	.001*
Developmental Level	106.00 (15.49)	73.21 (22.87)	.001*
ADOS			
Module 1 Single Words (N = 7)			
Raw Score	--	16.14 (range 9-22)	
Severity Score	--	7.00 (range 4-10)	
Module 2 (N = 6)			
Raw Score	--	14.00 (range 10-18)	
Severity Score	--	7.00 (range 6-9)	

Note. Receptive Language = Receptive Language subtest raw score from Mullen; Developmental Level = Early Learning Composite (standard score with *M* = 100, *SD* =15) on Mullen; Raw Score = Social Affect and Restricted and Repetitive Behavior Total using ADOS-G revised algorithms; Severity Score = Calibrated Severity Score of ADOS totals. Diagnostic cut-offs for ADOS revised algorithms are as follows: Module 1 Single Words *Autism* = 12, *Autism Spectrum* = 8; and Module 2 *Autism* = 10, *Autism Spectrum* = 7. Cut-offs for Severity Scores are as follows: *Autism Spectrum* = 4, *Autism* = 6.

Table 2

Predictable vs. Unpredictable Reaction Time Data (milliseconds)

	Transformed Predictable Reciprocal Latency Mean (SD)	Transformed Unpredictable Reciprocal Latency Mean (SD)	Overall Learning Effect
Across Groups			
Simple Condition	1762 (545)	1830 (634)	+68
Complex Condition	1782 (477)	1858 (524)	+76
Typical Development			
Simple Condition	1762 (448)	1785 (479)	+23
Complex Condition	1711 (311)	1836 (385)	+125
ASD			
Simple Condition	1762 (679)	1895 (823)	+133
Complex Condition	1883 (646)	1888 (691)	+5

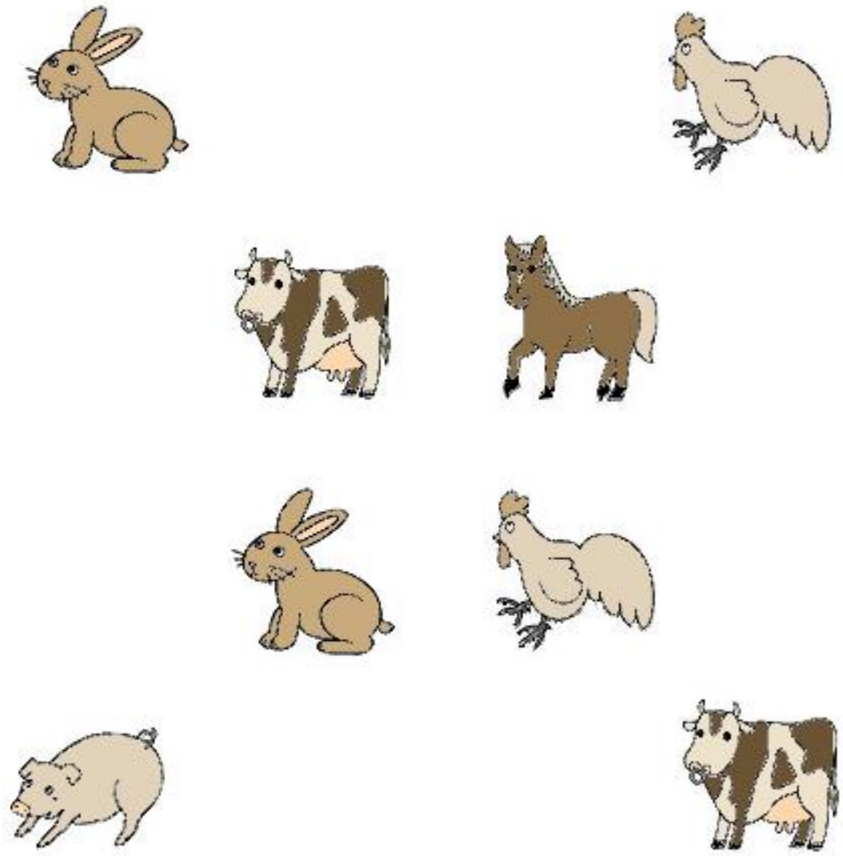

Figure 1. Pictorial representation of the farm animal stimuli. During predictive trials in the simple relationship condition, the location of the horse in the inner lower left quadrant is always be 100% predictive of pig's location in lower left quadrant.

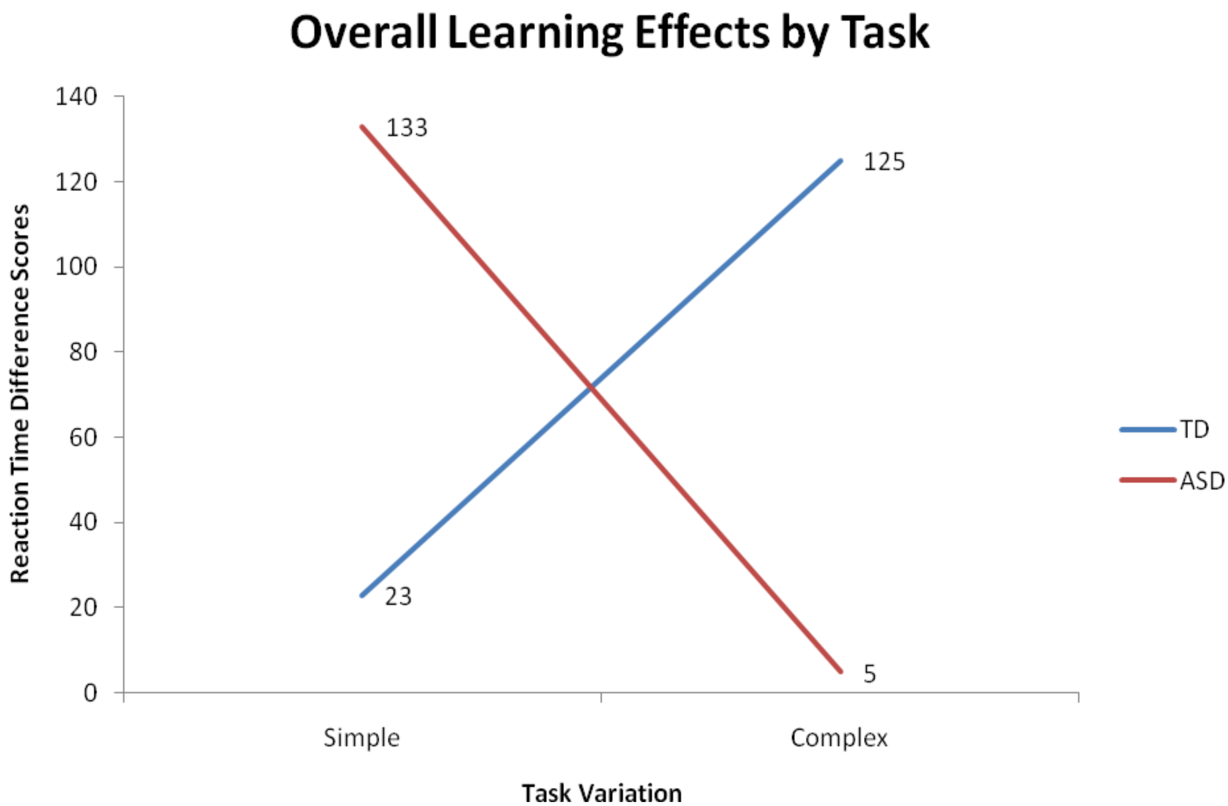

Figure 2. Difference scores in transformed reciprocal mean latencies of predictable and unpredictable trials by diagnosis under simple and complex task variations.