Development of a Computerized Task to Examine Differential Acquisition of Operant Responding in Autism Using Social and Non-social Discriminative Stimuli

by

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Abstract

Social skill deficits remain a defining feature of autism. One method to explain social behavior in autism is to explore specific antecedent-response relations. People with autism do not attend to social cues as readily as their typically developing peers thereby missing important cues that guide behavior during social interactions. The current study explored how children with autism learn antecedent-response relations using social and nonsocial stimuli as cues for reinforcement. A computerized task comprised pictures of social and non-social stimuli were presented on a computer screen. Participants were asked to respond to each picture by pressing a button if they thought pressing the button in the presence of the picture would earn them a reinforcer or to withhold pressing if they thought the picture would not earn them a reinforcer. Neither typically-developing children nor children diagnosed with ASD were able to reliably discriminate pictures. Developmental implications of these findings are discussed.

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Autism spectrum disorders (ASD) are complex neurodevelopmental disabilities characterized by qualitative deficits in social interaction and communication skills as well as restricted range of interests and/or repetitive behavior (American Psychiatric Association, 2000). Although specific genetic mechanisms have not yet been identified, converging evidence suggests that autism is genetically heterogeneous multiple interacting genes playing a major role in etiology (Anderson et al., 2007; Bailey, Phillips, & Rutter, 1996; Bolten et al., 1994; Folstein & Rutter, 1977, Pickles et al., 1995). Although the presence of a restricted repertoire of interests and delayed or absent language abilities can be debilitating, it is the deficits in social interaction skills that remain the core defining feature of autism spectrum disorders (ASD, Constantino et al., 2003; Matson & Wilkins, 2007; Weiss & Harris, 2001).

Social skill deficits in ASD fit into three broad and overlapping categories. The first is deficits in relating to others, which refers to the ability to understand the emotions, mental states, and actions of others. Relatedness is associated with constructs such as theory of mind, mind-blindness, and lack of empathy (Frith, 1989; Frith & Happe, 1994; Mundy et al., 1986). Second, individuals with ASD present deficits in non-verbal communication. For instance, they often have difficulty understanding, reacting to, and engaging in non-verbal communication. This category encompasses concepts such as joint attention, use of gesturing or referencing behaviors, following a gaze or point, and interpreting body language and non-verbal gestures (Baron-Cohen, 1988; Mundy et al., 1986). The third category involves lack of responsiveness to others. Lack of responsiveness occurs when there is no interest in social interaction unless there is a defined purpose, and this characteristic is often interpreted as a disinterest in social engagement (Filipek et al., 1999). The behaviors that fall into these three categories are rarely operationally defined in an objective manner. Often, the distinguishing factor between terms is theoretical orientation (Walton & Ingersoll, 2012). Moreover, there is little emphasis in the research with regards to how these broad deficits relate to each other to produce the social phenotype in ASD.

Need for Theoretical Foundation for Social Behavior

In addition to a lack of understanding of the interrelatedness between social skill deficits, there is no comprehensive underlying theoretical framework to explain the social phenotype in ASD. Existing theoretical orientations generally attempt to explain deficits in terms of a particular foundational skill (e.g., theory of mind, joint attention) that, when lacking or dysfunctional, impacts the ability to display more complex social behaviors that depend on its presence. However, it is unlikely that a single skill underlies the diverse pattern of social dysfunction seen in ASD. An important goal of this study is to develop a task to examine the possibility that social skill deficits in ASD involve behavioral processes, namely exploring the environment for the antecedents or cues that evoke social behavior, rather than a deficit in a particular foundational skill.

Lack of a unifying theoretical orientation has had a detrimental effect on treatment outcome in terms of acquisition, maintenance, and generalization of social skills in complex social environments. There are a multitude of clinical interventions to remediate social skill deficits in ASD, however, within that literature, there remain important gaps that warrant addressing. A review of social skill training interventions for youth with Asperger syndrome (AS) or high functioning autism (HFA) found that these treatments did not generalize to naturalistic environments (Rao, Beidel, & Murray, 2008).

Klin, Schultz, and Cohen (2000) propose that the removal of context in the treatment and research of social skills plays a critical role in the inability of individuals with ASD to display these skills in natural settings even though they perform well in simplistic experimental and clinical contexts. Furthermore, the definition of social skills in ASD has not been consistent across studies (Rao et al., 2008). Although, there is some overlap across definitions of social skills (e.g., many definitions include behaviors such as eye contact, and initiating conversation), most definitions also incorporate idiosyncratic and complex behavior patterns (e.g., self control, and problem solving) that make comparisons across studies and translation to intervention difficult. It is imperative that researchers provide consistent, objective, and observable definitions of social skills to facilitate inter-rater agreement, the evaluation of treatment efficacy, and comparison across studies. To overcome these limitations, Rao and colleagues (2008) recommended that researchers investigate specific deficits in AS and HFA. Likewise, they recommended that social skill training should be tailored to address the specific needs (deficits) of children with ASD. Finally, social skills training programs need to be designed to promote skill generalization outside the clinical and experimental settings by providing multiple opportunities to interact with new people and in different environments. In viewing social skill deficits from a behavior analytic perspective, we hope to explain some of the variability noted in social function in ASD by addressing these variables. Such clarification of the social phenotype in ASD will help develop a treatment algorithm that can more effectively target existing effective treatments (Walton & Ingersoll, 2012; Campbell, 2003; McConnell, 2002; Rao et al., 2008; Reichow & Volkmar 2010; Rogers 2000; Weiss & Harris, 2001; White, Keonig, & Scahill, 2007; Ramdoss, Machalicek, Rispoli, Mulloy, Lang, & O'Reilly, 2011).

Advances in research on social skill interventions will be contingent on methodological improvements that increase specificity in descriptions of the social phenotype in ASD and lead to viable theoretical frameworks regarding the etiology of social skill deficits in this group. Hodapp and Dykens (1994, 2005, 2007) discuss three important methodological needs in research on the social phenotype in ASD and other intellectual disabilities: direct observation, objective definitions, and novel tasks. They recommended that researchers focus on operationally defined behavior as opposed to summary labels. This will allow clinicians to target specific skill deficits. The development of novel tasks, questionnaires, and more direct observational methods for the study of social behavior within a natural setting would best serve to capture the context in which social behavior occurs (Dykens & Hodapp, 2007; Hodapp & Dykens, 2005; Kennedy, Caruso, & Thompson, 2001; Klin et al., 2002). However, basic experimental tasks that capture the complexity of the natural context have been key in elucidating important behavioral mechanisms of social skills while overcoming the pitfalls of naturalistic studies (Klin et al., 2002; Grelotti, Gauthier, & Schultz, 2002). Accordingly, an important goal of the current study was to develop a method by which to evaluate responding to social cues in a complex context using a basic experimental task.

Researchers have identified the methodological needs to be addressed in order to uncover the fundamentals of social behavior in autism (Dykens & Hodapp, 2007; Hodapp & Dykens, 2005; Kennedy, Caruso, & Thompson, 2001; Klin et al., 2002). Applied behavior analysis (ABA) offers a platform in which these needs can be addressed.

Stimulus Control as a Conceptual Framework for Social Behavior

Behavior analysis can provide a theoretical foundation that ties together fundamental aspects of social behavior and accounts for some of the variability in social aptitude in autism by exploring behavioral principles that underlie social behavior. One principle that may be essential in interpreting social behaviors such as lack of responsiveness to others is stimulus control.

Stimulus control is a process by which a stimulus in our environment signals to us that a certain behavior will be reinforced or punished. Namely, engaging in a behavior (e.g., sitting down) in the *presence* of a discriminative stimulus (e.g., music stops in a game of musical chairs) will result in a consequence (e.g., staying in the next round or winning the game), while engaging in a behavior in the *absence* of a discriminative stimulus will result in no consequence (Martin & Pear, 2015). So, while consequences such as reinforcement or punishment teach us what to do (i.e., sit in a seat to win the game), the process of stimulus control helps us understand the context in which we should do it (i.e., only when the music stops). Stimulus control is said to be robust when the relation between the discriminative stimulus, the behavior, and the reinforcer are strong. A stimulus could also acquire control over response omission by signaling either punishment or extinction.

For example, in social contexts eye contact could be established as a discriminative stimulus signaling that greetings such as “hello” are likely to be reinforced with social attention. Conversely, in the absence of eye contact, “hello” may not be followed by social attention. It has been postulated that children with autism do not discriminate social cues, such as eye contact, or gestures for social initiation. Therefore, it is possible that social skill deficits in autism may stem from poor stimulus control. That is, social stimuli may not serve as effective signals for reinforcement. However, this has not been tested directly and empirically.

Dawson (2008) argued that the social deficits in ASD are due to impairment in "social motivation". The social motivation Hypothesis states that children with ASD do not readily engage in social interaction because they do not attend to and discriminate social stimuli (Dawson, Webb, Wijsma, et al., 2005; Dawson, Carver, et al., 2002; Grelotti, Gauthier, & Schultz, 2002; Waterhouse, Fein, & Modahl, 1996). In behavioral terms, Dawson and colleagues propose that people with ASD fail to attend to social stimuli because they have not acquired stimulus control. Moreover, the term "motivation" suggests that the behavior of people with ASD is not reinforced by social stimuli, and subsequently they do not attend to or engage socially.

While there is no direct evidence to show that stimulus control processes are disrupted with regards to social interactions in ASD, Klin and colleagues (2002) provide suggestive evidence through the analysis of gaze patterns in people with autism and without autism while viewing video clips of socially-complex movie scenes. They used eye-tracking technology to examine four spontaneous gaze patterns: looking at faces, social monitoring, looking for social information in other's reactions to the speaker, attending to physical versus social cues, and sensitivity to nonverbal social cues. These patterns were later correlated with the outcome measures of social competence (VABS-E socialization scores and ADOS social scores) of participants. They found that people with autism focus predominantly on the mouth when looking at faces. Moreover, there was a positive correlation between the amount of time spent attending to the mouth and level of social competence. Those who were less socially competent spent more time looking at objects while those who were more socially competent spent more time looking at the mouth area when engaged in social interaction. This suggests that when there is social competence, the process by which it develops in individuals with autism is different than the process by which it develops in typically developing individuals. Thus, it is not enough to study skill deficits or even social outcomes (i.e., the consequences of social behavior or lack of social behavior) in ASD. We must also study the *process* by which individuals with ASD achieve a given social outcome as compared to that process in typically developing individuals (Klin, Lin, Gorrindo, Ramsay, & Jones, 2009).

The most direct evidence of a stimulus control issue specific to social stimuli comes from their analysis of gaze patterns in non-social contexts. In one scene from the film *Who's Afraid of Virginia Woolf?* (1966), a hand reaches for a gun. Klin and colleagues (2002) found that not only do people with ASD attend to the important non-social cues (i.e., hand reaching for a gun) but they actually anticipated the non-social cues *faster* than the typically developing youth. Thus, individuals with autism are sensitive to physical cues in a non-social scene.

These findings are consistent with the view that social stimuli may not serve as antecedents for social interaction in this population. It is possible that by focusing on objects, individuals with autism fail to attend to social cues. In doing so people with autism may often miss social cues that are integral to social interaction and social convention. Taken together, different from the norm gaze patterns for scenes with rich social context along with faster than normal eye gaze responses to physical cues suggests that difficulties in attending to cues are specific to social information or contexts in individuals with ASD.

Stimulus control provides one way to examine and interpret the social skills deficits found in ASD. It is possible that social stimuli may not serve as signals of reinforcement for people with ASD. Klin et al. (2002) have used novel experimental paradigms to explore behavioral mechanisms and specify a variety of phenotypic behaviors in individuals with intellectual and developmental disabilities particularly in the area of social behavior. However, there is still no underlying theoretical framework to interpret these findings nor is there a way to quantify the range of these deficits. Exploring the behavioral mechanisms that underlie social skill deficits could provide a conceptual basis to these findings. One way of exploring the behavioral mechanisms that has proved successful in the past and could be used as a model on which to conceptualize the current study is the development of functional analysis technology.

Functional Analysis: A Model for Developing a Theoretical Framework

The behavior-analytic approach has been successful in providing a unifying framework for the assessment and treatment of problem behavior and resulted in the methodology of functional analysis (FA), which allows us to more effectively target treatments for self-injury, aggression, and other problem behavior. Functional analysis is an experimental approach to assessment based on operant methodology that manipulates antecedents and consequences of problem behavior in order uncover its functional properties (Iwata, Dorsey, Slifer, Bauman, & Richman, 1994). The application of functional analysis has proved to be extremely useful in the assessment of self-injurious behavior and other problem behaviors in individuals with intellectual and developmental disabilities because it allows practitioners to choose treatments for problem behavior that directly match the function or purpose of the behavior. Treatments that are matched to behavioral function have been shown to be much more effective (and less restrictive) than treatments that are not matched to behavioral function (Mace & Mauk, 1995). Although the development of functional analysis methodology had a significant impact on clinical approaches to treating severe problem behavior, the theoretical implications of this model are often overlooked. Specifically, the exploration of behavioral mechanisms that underlie behavioral deficits and excesses have not been generalized to other areas of functioning such as social skills.

Functional analysis has been successful in elucidating the behavioral functions that maintain problem behaviors. In this framework, topographically dissimilar problem behaviors may be grouped together according to their behavioral function. Function-based interventions target the current motivational variables that maintain problem behavior. For instance, when trying to reduce the frequency of a problem behavior such as tantrum, the maintaining variable (e.g., social attention, escape from demands, etc.) is removed. Consequently, identifying the functions of problem behavior helped improve our treatment of these behaviors because it provided a theoretical framework for targeting treatment more effectively. In a similar manner, identifying the behavioral mechanisms that underlie social behavior in autism may allow us to group functionally similar skills and skill deficits and increase the efficacy of our social skill interventions by targeting their behavioral etiology.

If we could begin to understand the behavioral processes that disrupt social functioning in ASD, then we could create "functional phenotypes" based on social skill deficits that share similar behavioral mechanisms (Caruso-Anderson, Paclawskyj, Kurek, & Hagopian, 2009). The purpose of the current study was to explore the behavioral principles that produce the functional phenotypes in ASD by directly assessing the ability of individuals with ASD to learn response-consequence relations when social and non-social cues are used as discriminative stimuli. Understanding behavioral processes (e.g., stimulus control) that contribute to social skill deficits and inappropriate social behavior will make it possible to target a wide variety of interventions available in much the same way that FA technology helped to target behavioral intervention for problem behavior.

Purpose

The findings of Klin et al. (2002) suggest that social stimulus control may be dysfunctional in individuals with ASD, and that exploring this behavioral principle may provide a framework to characterize social deficits. Klin et al. (2002) have used novel experimental paradigms to explore behavioral mechanisms of social behavior and have specified a variety of phenotypic behaviors in individuals with intellectual and developmental disabilities. Their methods have provided indirect evidence that stimulus control specific to social situations is lacking. There still is a need to test this phenomenon directly. The development of a novel basic experimental task that simulates as closely as possible the complexity of the natural setting would be best in capturing the context of social behavior (Dykens & Hodapp, 2007; Hodapp & Dykens, 2005; Kennedy, Caruso, & Thompson, 2001; Klin et al., 2002).

There has been extensive literature on the processing of facial recognition (Harms, Martin, & Wallace, 2010; Klin et al. 2009) and emotions in individuals with ASD as well as literature on visual discrimination skills (Mitchell & Ropar, 2004; Simmons et al., 2009) with regard to non-social tasks. However, there appears to be a lack of studies that specifically examined stimulus discrimination processes within social contexts. The aim of the current study was to build on current literature on facial recognition and discrimination of emotional states to assess more complex social contexts, for instance by varying the contingencies for behavioral responses. Accordingly, we wanted to develop and test a task using simple stimuli such as faces and then be able to adjust the complexity of the task by changing response contingencies to systematically simulate the range of complexity in real life social situations. Furthermore, if stimulus control is lacking, the severity of this deficit would be expected to vary across individuals. Accordingly, a second aim of this study was to develop a task that facilitates exploration of the range of contexts in which stimulus discrimination may or may not occur. There are contexts that serve as clear antecedents for social interaction as well as for no social interaction. However, there are also ambiguous contexts in which the antecedents may not be clear or the reinforcers may not be consistent. The research questions addressed in this exploratory task were: 1) In what contexts, do people with ASD display stimulus control in response to non-social and social stimuli; and 2) How do discrimination skills in people with ASD compare to discrimination skills in typically developing individuals in terms of both process and outcome. The purpose of this study goes beyond empirically establishing that children with ASD do or do not display discrimination skills in the presence of social stimuli. An additional goal is to explore the parameters of discrimination skills in ASD if they are present. Specifically, this task will establish developmental norms for discrimination of social stimuli by including a typically developing peer group; will examine how the process of discrimination may differ between social and non-social stimuli, and will explore how ambiguity affects the process of discrimination of social and non-social stimuli. This was a desired approach considering that there is a lack of standardized data on the development and use of discrimination skills in social contexts for individuals with ASD as well as their typically developing peers.

Consequently, the goal of my study was to develop and test a computer stimulus control task to determine the extent to which social stimuli serve as a discriminative stimulus for reinforcement as compared to non-social stimuli. An important additional goal was to assess differences in the stimulus control process between people with ASD and their typically developing peers by including increasingly complex contexts (e.g., through manipulation of the range of emotions presented, by introducing ambiguity into the response-consequence relation through the manipulation of reinforcement schedules, etc.). The stimulus control task was designed to assess the salience of social stimuli by comparing participants' ability to learn antecedent-response–consequence relationships in the presence of social and non-social stimuli.

Hypotheses

The purpose of our task was to explore how participants responded to social and non-social stimuli, and to determine if they were able to contact the antecedent-response-consequence contingencies as indicated by their number of correct responses and amount of errors committed; their respective discrimination indices. It was expected that over successive trials participants with ASD would capture the contingencies around the non-social stimuli more readily than for the social stimuli as indicated by committing more correct responses and fewer errors, and that they would acquire the antecedent-response consequence contingency as indicated by their discrimination index ratio. Conversely, typically developing participants would capture the contingencies around the social stimuli more readily than for the non-social stimuli as indicated by committing more correct responses and fewer errors and that they would score a moderate to high discrimination index ratio. With regard to introducing ambiguity to the antecedent-response-consequence, it was hypothesized that both participants with ASD and typically developing would commit more errors than correct responding because the contingency would not be clear. Furthermore, that the discrimination ratios calculated for the ambiguous stimuli for each participant would be moderate to low.

Method

Participants and Setting

There were 10 participants, six of them were males with ASD (P1, 2, 3, 4, 5, and 6) (M_{age} = 9.67, range = 8 -11 years of age), and 4 participants were typically developing males (P7, 8, 9, and 10) (M_{age} =6.75, range = 6 -9 years of age). All participants were required to be familiar with and have had some experience working with a computer such as typing with the keyboard. Participants must have demonstrated that they have skills essential to the computer task. These included matching, object identification, the ability to follow instructions, and the ability to work at a table for at least 10 minutes. Sessions were approximately 60 minutes in length and took place in the participants' homes. One to two sessions maximum were required per participant. Participants were recruited from Manitoba. Recruitment in Manitoba was conducted through a community agency providing services to children with ASD.

ASD group inclusion and exclusion criteria. Research has established that there is a greater proportion of males with ASD than females (Fombonne, 2003). Additionally, symptoms of ASD, particularly social skill deficits, vary depending across genders (Lord, Schopler, & Revicki, 1982). Accordingly, females were not included in this study because doing so would have introduced excessive variability within the data. With the exception of ADHD, participants were excluded if they had a co-morbid genetic, neurological, or psychiatric disorder. Participants who were eligible must have received a previous diagnosis of ASD from a clinical psychologist or psychiatrist. Participants recruited from the service agency received confirmation of diagnosis of ASD at intake into the program. Participants recruited had the following assessments completed upon entry to the program: the Wechsler Preschool and Primary Scale of Intelligence (WPPSI), CELF-preschool, Scales of Independent Behavior-Revised (SIB-R short form), PDDBI, VBMAPP (Verbal Behavior Milestones Assessment and Placement

Program), and the Assessment of Basic Learning Abilities (ABLA). To be included in this study, participants were expected to have scored at least a Level 3 on the ABLA indicating that they are able to perform visual discrimination tasks (Kerr, Meyerson, & Flora, 1977).

Inclusion and exclusion criteria for typically developing children. Typical developing participants had a history of typical development as confirmed by their parents. Parents also confirmed the absence of co-morbid psychiatric or developmental disorders. Typical developing participants were currently placed in either a general educational or daycare setting, and did not qualify for or receive special education services at the time of the study.

Independent and Dependent Variables

The independent variables included stimulus type (social or non-social) and diagnosis (ASD or typically developing control group). The dependent variable was the acquisition of antecedent-response-consequence relations operationalized by, discrimination index ratios, errors of commission (EoC) and errors of omission (EoO) across population and stimuli type. The discrimination index ratio measures the degree to which a participant acquired discrimination. The ratio is a proportion calculated by taking the number of responses to the stimuli that were assigned reinforcement and dividing that by the number of responses to stimuli assigned reinforcement plus stimuli assigned no reinforcement. The discrimination index computes a value between 0 and 1, where values of 0 = perfect inverse discrimination, values of .5 = no discrimination, and values of 1 = perfect discrimination. Errors of omission occur when a response fails to occur to a stimulus that is associated with reinforcement. Errors of commission occur when a response occurs to stimuli that are associated with no reinforcement. Response patterns to ambiguous stimuli were also evaluated.

Stimuli and Apparatus

The current study evaluated learning of antecedent-response-consequence relationships to social (pictures of faces) and non-social (pictures of skies) stimuli. Social stimuli consisted of NimStim images depicting happy, neutral, and angry faces (Tottenham et al., 2009). The NimStim Set of Facial Expressions is a standardized set of images depicting eight human emotions: happy, sad, angry, fearful, surprised, disgusted, neutral, and calm and was used with permission (personal communication; Tottenham, January 30, 2012, Tottenham et al., 2009). The images were of both sexes and multiracial (European-American, African-American, Hispanic-American, and Asian-American). Non-social stimuli consisted of pictures of skies: sunny skies with white puffy clouds, clear blue skies (no sun, or clouds), and stormy skies depicting lightning. The sky pictures were obtained using Google® images.

All pictures were repalleted to a 250-colour palette and resized to a width of 498 pixels and a height of 640 pixels (10 x 12.85 cm, with 49.80 pixels per cm) using Adobe Photoshop Elements 10 (Adobe Systems Incorporated, 2011). The resolution of the pictures was held constant. The pictures were programmed into a computerized task using the software E-Prime 2.0 (Psychology Software Tools, Inc., Sharpsburg, PA). The tasks were conducted on a notebook computer with a 33 cm screen.

Procedure

Preference assessment. Edibles were used as reinforcers and were earned throughout the computerized tasks. Edibles were used mainly because they are easily consumed and quickly administered. The reinforcers were determined through a multiple stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996). In the MSWO assessment, all items were sequenced randomly in a line in front of the participant. The participant was instructed to select one item and permitted to ingest the edible. Once selected, the item was not replaced in the array. The remaining edible items were rearranged so that they were equally spaced apart. This procedure continued until all items had been selected or until all that was left were the items the participants had not selected.

Ease of conditioning: the computerized task. Participants and caregivers sat at a table with the notebook computer positioned directly in front of the child. The experimenter sat perpendicular to the child to ensure that both the computer screen and container for reinforcers was within the child's view. Participants were shown on the computer screen, pictures of faces (happy, angry, and neutral) and skies (sunny with white clouds, clear, and stormy). Each of the stimuli was assigned a consequence that was unlikely to correlate with the individuals' reinforcement histories (e.g., happy faces and sunny skies being associated with reinforcement, etc.). Stimuli (S^+) associated with receiving a reinforcer (S^+) included neutral faces and clear skies. Button presses to happy faces and sunny skies with white clouds (S^-) were not associated with reinforcement (i.e., button presses to these stimuli were on extinction). The third set of stimuli (i.e., angry faces and stormy skies with lightning) was called ambiguous stimuli ($S^?$) because responses to these stimuli were randomly reinforced on 50% of trials. That is, responses to S^+ and 50% of $S^?$ stimuli resulted in the delivery of a reinforcer while responses to S^- and the remaining 50% of $S^?$ stimuli did not result in delivery of a reinforcer. The set of ambiguous stimuli were included to examine patterns of responding in a "complex (i.e., unpredictable)" context. That is, we wanted to assess the effect of intermittent reinforcement on discrimination of clearer contingencies such as those associated with the S^+ and S^- stimuli as measured by response patterns, EoC's and EoO's, between individuals with autism and their typically developing peers. This manipulation was designed to assess this aspect of the complexity of social interaction in isolation from other social contexts.

The task was presented in three blocks of trials: one block of 40 practice trials, and two blocks of 100 test trials. Each of the computer tasks contained an introduction slide with the written task instruction that the experimenter read aloud. The practice trials consisted of 40 trials and evaluated comprehension of the instructions. Stimuli included in the practice trials were not included in the testing trials. Based on their performance on the practice trials, the instructions were modified to facilitate comprehension for a few of the participants. For example, "press the green button only if you think that picture will earn you a <edible>, if not, do not press the button".

Following the practice trials, the participants were offered a short break of 5 minutes to consume the edibles they had earned from the practice trials, or to continue on to the first block of testing trials. The testing trials began with the first slide containing the same instructions and then advanced to the first picture within that set. The two testing blocks (Block 1 and Block 2) consisted of 100 trials each, both containing different stimuli.

The computer tasks were programmed to measure response time for button presses. The software was programmed to present the corresponding feedback and then advance when the participant touched the green button or after 5 seconds if the participant did not respond. Therefore, the tasks were programmed to have a 5 s inter-trial interval. The order of pictures in the task presentation for the practice and testing sets of trials were randomized with the exception of the first trial of the ambiguous stimuli within the practice set, which were correlated with receiving the reinforcer (i.e., the first trial containing a storm cloud with lightning, and the first containing an angry face). These two trials resulted in the delivery of a reinforcer for button pushes to allow participants to contact the contingency. The rationale for this was that the ambiguous stimuli would randomly produce reinforcement 50% of the time, but the first ambiguous stimulus should produce reinforcement. If the child does not contact reinforcement early in response to ambiguous stimuli, they may respond to all ambiguous stimuli as if they are S^- (i.e., the sunny and happy faces).

Two versions of the computerized task were created based upon the performance of the first four participants. The two versions of the protocol will be referred to as: 1) omissions not reinforced in which correct omissions-participant was correct by withholding button pressing for certain stimuli were not reinforced; and 2) omissions reinforced- participants were reinforced for correctly withholding button pressing for certain stimuli.

Omissions not reinforced. Participants 1, 3, 6, and 7 had the opportunity to respond to the pictures presented on the screen by pressing the “f” key on the keyboard marked with a “green” sticker or to withhold responding. These participants were instructed to press the button when they saw a picture associated with the reinforcer and to refrain from pushing the button if the picture was not associated with reinforcement. Instruction and introduction to the computer tasks were minimal as the goal was to assess acquisition in the presence of social and non-social stimuli. Once seated for the task, the participants were given the following instructions:

> "You are going to play a game to earn an edible. During the game, you will see pictures of skies and faces. Some pictures will earn you an edible if you touch the GREEN button and some of the pictures will not earn you an edible if you touch the GREEN button. You can win the game by learning which pictures earn you an edible when you press the GREEN button, and which pictures earn you an edible by NOT pressing the green button. START by pressing the SPACEBAR"

Thus, the participant would learn which stimuli lead to reinforcement and which do not through the programed contingency. Edible reinforcers were delivered in a container (e.g., cup, bowl) for consumption once the task was completed. During the task, the child was able to see the edible reinforcer being placed in the container each time they make a correct response when pressing the green button. The cup was visible but out of reach during the task. The top three edibles identified in the MSWO were re-presented in-between blocks of trials to determine which edible the participant wanted to earn for the next block of trials.

All three blocks of trials (practice, testing block1 and block2) were programmed to provide a feedback display after every trial indicating one of three possible consequences: 1) a correct feedback slide appeared and remained on the screen for 2 s if the child pressed the green button to either a neutral face or clear sky and 50% of the ambiguous stimuli (i.e., lightning, and angry faces). The two-second interval for the correct feedback display was sufficient to identify a correct response to the participants and also served as a prompt for the experimenter to administer the reinforcement into the container when appropriate. 2) The picture remained on the screen for 7 s if the child incorrectly pressed the green button (i.e., EoC) to the happy faces, sunny skies, and to the other 50% of the angry faces and lightning pictures. The picture remaining on the screen for an additional 7 seconds indicated an incorrect response. The rationale for the 7 s delay was to discourage indiscriminate button pressing (i.e., an exceedingly high number of EoC) which was observed in a few participants during piloting. 3) A "no response detected" message appeared and remained on the screen for 2 s if the child refrained from pressing the green button on trials for which the stimuli were assigned reinforcement for pressing the button (i.e., neutral faces, clear skies, 50% of angry faces, and 50% of lightning). This feedback was only to inform the experimenter that the participant did not press the green button.

Omissions reinforced. After analyzing participants 1, 3, 6, and 7's performance on the task, it was observed that a disproportionately high amount of errors of commission occurred which appeared to skew performance toward button pressing. To shape performance on the task for the subsequent participants (P2, 4, 5, 8, 9, and 10) it was agreed to provide reinforcement not only when the participant correctly pressed the button but also for withholding button presses to the S^- stimuli (i.e., the sunny skies, happy faces, and 50% of angry faces and 50% of lightning). These responses were identified as correct omissions and counted as correct responses as well. The rationale behind this was that social behavior also involves withholding or inhibiting responses in certain contexts and the goal was to examine this type of stimulus control as well.

The instruction and introduction to the computer tasks was modified from the previous version to reflect that correct omissions would be reinforced. Once seated for the task, participants were given the following instructions:

> "You are going to play a game to earn an edible. During the game, you will see pictures of skies and faces. Some pictures will earn you an edible if you touch the GREEN button and some of the pictures will earn you an edible if you do NOT touch the GREEN button. You can win the game by learning which pictures earn you an edible when you press the GREEN button, and which pictures earn you an edible by NOT pressing the green button. START by pressing the SPACEBAR"

Edible reinforcers were delivered in a container (e.g., cup, bowl) for consumption once the task was completed. During the task, the participants were able to see the edible reinforcer being placed in the container each time they make a correct response when pressing the green button or when they correctly withheld pressing the button for the stimuli that were associated with non-response. The cup was visible but out of reach during the task. The top three edibles identified in the MSWO were re-presented in-between blocks to determine which edible the participant wanted to earn for the next block.

Similarly to the omissions not reinforced version, the practice and testing blocks 1 and 2 were programmed to provide a feedback display after every trial. If the child pressed the green button to either a neutral face or clear sky and 50% of the ambiguous stimuli (i.e., lightning, and angry faces) a correct feedback slide appeared and remained on the screen for 2 s. Unique to the omissions reinforced version was that a correct feedback slide was also programmed to appear if the participant withheld pressing the green button to the happy faces and the sunny skies, as well the other 50% of the ambiguous stimuli. If the child incorrectly pressed the green button (i.e., EoC) to the happy faces, sunny skies, and to the other 50% of the angry faces and lightning pictures, the picture remained on the screen for 7 s. A "no response detected" message appeared and remained on the screen for 2 s if the child refrained from pressing the green button on trials for which the stimuli were assigned reinforcement for pressing the button (i.e., neutral faces, clear skies, 50% of angry faces, and 50% of lightning). The two second feedback display for non-responding was to ensure that it did not discourage withholding responses because withholding was also counted as a correct response to the sunny skies and happy faces pictures. A summary of the contingencies can be found in Table 1.

Data Analysis

Discrimination ratios. A discrimination index calculator was created using excel to determine the degree of discrimination learning displayed by the participants' performance on the computer task. The discrimination index calculator produced two values: one for discrimination learning for the stimuli assigned a clear consequence (e.g., neutral faces, clear skies, happy faces, and sunny skies) and one for the ambiguous stimuli that received 50/50 reinforcement for button presses and correct omissions (e.g., angry faces and lightning). The calculation logic behind the discrimination index calculator was based on the discrimination index ratio used in Dittrich and Lea (1993) in which they took the number of responses during S^+ divided by responses to S^+ plus responses to S^-. In other words, responses to the stimuli that were assigned reinforcement divided by responding to the stimuli assigned reinforcement plus responding to stimuli assigned no reinforcement. The calculation also factored in the dependent variables: EoO and EoC by counting the number of each error type and using these proportions to calculate the discrimination indices. Discrimination indices were also calculated by stimuli type according to their assigned consequence. The calculator provides proportional indices even if S^+ and S^- have uneven number of trials. It weighted similar

Table 1

Summary of Reinforcement Contingency

Omissions not reinforced protocol

Stimulus	Response	Consequence/ Feedback
S^+ (neutral face/ clear sky)	Press green button	"Correct" and edible
S^- (happy face/ sunny sky)	Withhold button press	"No response detected"
	Press the button	Picture on screen for 7 seconds
$S^?$ (angry face/ lightning)	Button press (50%)	"Correct" and edible
	Withhold (50%)	"No response detected"

Omissions reinforced protocol

Stimulus	Response	Consequence/ Feedback
S^+ (neutral face/ clear sky)	Press green button	"Correct" and edible
S^- (happy face/ sunny sky)	Withhold button press	"Correct" and edible
	Press the button	Picture on screen for 7 seconds
$S^?$ (angry face/ lightning)	Button press (50%)	"Correct" and edible
	Withhold (50%)	"Correct" and edible

both responses and omissions. The interpretation key for the discrimination index was based on that used by Herrnstein, Loveland, and Cable (1976) in which they used a range from 0-1 with values of 0 = perfect inverse discrimination, values of .5 = no discrimination, and values of 1 = perfect discrimination. The study by Dittrich and Lea (1993) used a range of .65 or 65% and higher to determine success at discrimination. Therefore, the present study determined that a discrimination index ratio between .65 and .74 indicated moderate success at discrimination, .75 to 1.0 near perfect discrimination, and values between .5 and .64 indicated no success at discrimination.

Response patterns across time. Graphs were created for each participant examining correct responding (both correct button presses and correct omissions) over time across trials for both social and non-social stimuli. The graphs depict participant responses divided by blocks of 10 trials from the practice set to the two testing blocks (1 and 2). Due to the random presentation of trials throughout the computer task, it was not always feasible to divide into exact block of 10 trials for our analysis. Therefore, between 1 and 9 trials at the beginning of the practice set were removed from the data analysis to create even blocks of 10 across entire computer task. This facilitated an evaluation of participant performance across the experiment over time and trials.

Results

Discrimination Index Ratios

Participants' discrimination index ratios can be found in Table 2, organized by diagnostic group (ASD and Typically developing) and computer task version (omissions reinforced and omissions not reinforced). The ratios reflected responding to the clear consequence stimuli only (e.g., neutral faces, clear skies, and the happy faces and sunny skies). It was determined during analysis that the discrimination index ratios for the

Table 2

Discrimination Ratios for Clear Consequence Stimuli (Neutral Faces, Clear Skies, Happy Faces and Sunny Skies).

Participants in the Omissions not reinforced Protocol Group

ASD	Overall	Testing Block 1	Testing Block 2
P1	.75	.75	.76
P3	.55	.51	.76
P6	.69	.70	.70
TYP			
P7	.66	.59	.71

Participants in the Omissions Reinforced Protocol Group

ASD	Overall	Testing Block 1	Testing Block 2
P2	.59	.58	.57
P4	.93	.90	.94
P5	.60	.62	.54
TYP			
P8	.64	.64	.62
P9	.70	.58	.73
P10	.64	.70	.48

Note. A discrimination index ratio between .5 and .64 = no discrimination, .65 to .74 = moderate discrimination, and .75 to 1.0 = near/perfect discrimination.

ambiguous stimuli did not provide meaningful information because the contingencies for responding or withholding a response varied randomly. Table 2 displays three discrimination ratios: one for overall performance on the clear consequence stimuli as well as discrimination ratios based on performance in the two testing blocks. According to our conservative criterion, the overall ratios for participants 2, 3, 5, 8, and 10 indicated no discrimination. The overall ratios for participants 6, 7, and 9 indicated a moderate success at discrimination. Lastly, participants 1 and 4 had a discrimination ratio that was near to perfect.

The rationale for calculating ratios for the two testing blocks was to examine whether participants were able to capture the contingency as a result of performance over successive trials. Participants 3, 7, and 9 show improvement from testing block 1 to block 2 in that their ratios increased from "chance" performance to "moderate discrimination" (P7) or in the case of P3 and P9 "near perfect" discrimination. This finding represents those participants who captured the contingency with regard to the stimuli in the latter half of the protocol as opposed to participants 1, 4, and 6 who had consistent moderate to near perfect ratios in both testing blocks 1 and 2. The remainder of the participants demonstrated either consistent "random" performance or decrements in performance. These findings are encouraging because it appears that more participants demonstrated discrimination than initially thought judging by their overall performance ratios. For participants 3, 7, and 9, time (number of trials) and poor performance early on in the protocol impacted their overall performance. Moreover, these discrimination ratios are aggregated across both social and non-social stimuli and some participants (e.g., P9 and P1) only improved in the last half for one type of stimuli while the other continued to show the random pattern (i.e., social and non-social stimuli respectively).

Response Patterns

Figures 1 and 2 contain graphs depicting each participant's correct responses over successive trials for social and non-social stimuli that were assigned a clear consequence (e.g., neutral faces and clear skies; happy faces and sunny skies). The majority of participants from both groups displayed random response patterns to both sets of stimuli as reflected in the number of peaks and valleys. Figure 1 depicts the performance graphs for participants with ASD, the line denoted with open circle markers represent the non-social stimuli and the lines with the diamond markers are the social stimuli. The left column contains the graphs of the participants who received the omissions not reinforced protocol. The right column contains the graphs of the participants who received the omissions reinforced protocol.

With regard to social stimuli, participant 1's pattern appears to be an upward trend in the amount of correct responses across trials, which may have contributed to him having a high discrimination ratio. For non-social stimuli, his pattern of responding appears to have an upward trend however it also unstable with a fluctuation between high a low points.

Participant 3's performance on the social stimuli appears to be unstable in the amount of correct responses across trials, which may have contributed to him not meeting criterion for discrimination. With regard to the non-social stimuli, participant 3 appeared to have a fairly stable trend with an increase in correct responding at the 60th trial.

Participant 6's performance in terms of correct responding to the social stimuli appears unstable. His performance improves dramatically from the 50 trial block to 60. However, his performance gradually decreases toward the end. Participant 6's

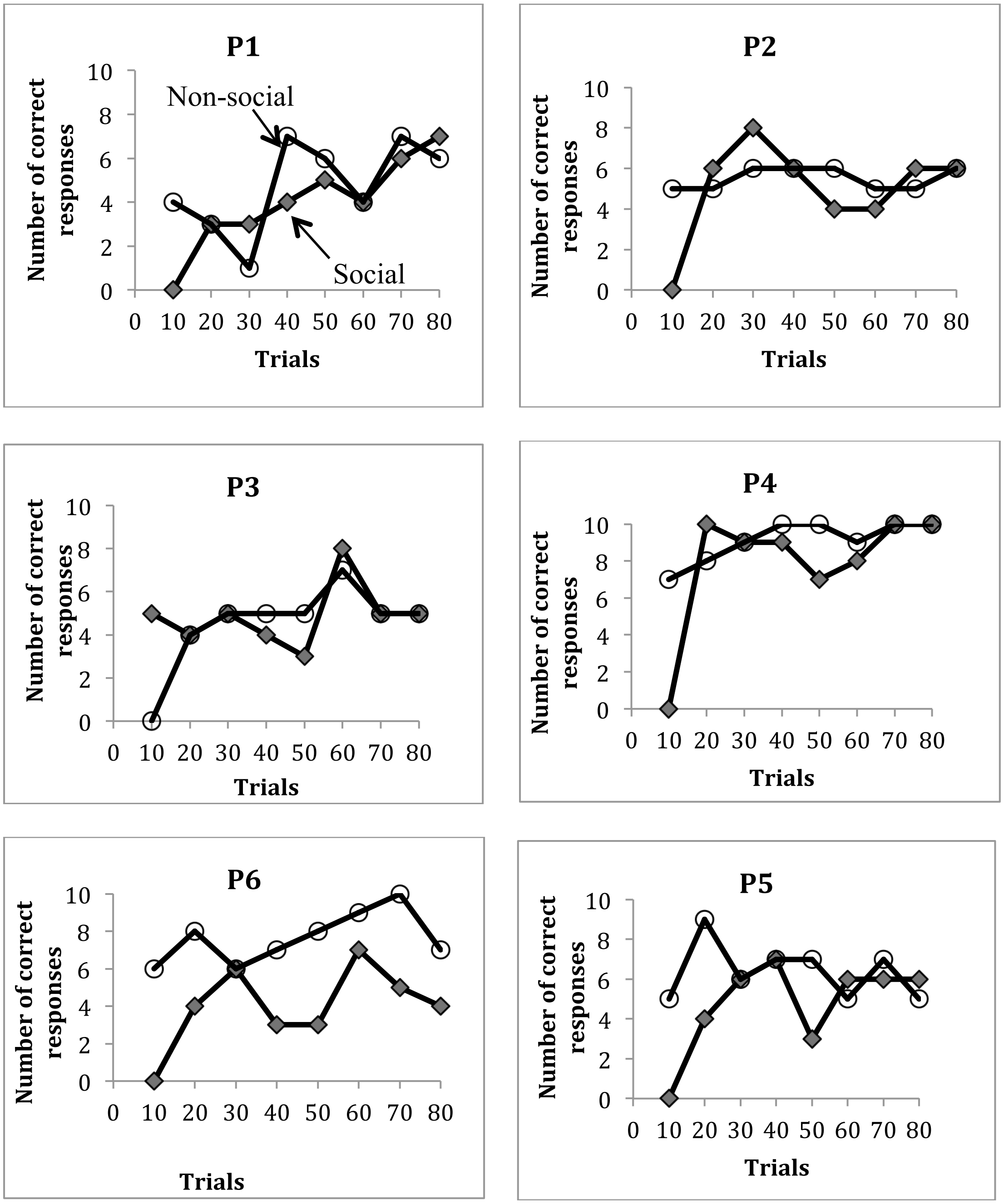

Figure 1. Displays the number of correct responses for both correct button presses and correct omissions on the social stimuli assigned a clear consequence (e.g., neutral faces and happy faces) and the non-social stimuli assigned a clear consequence (e.g., clear skies and sunny skies) for participants with ASD. Participants 1, 3, and 6 received the omissions not reinforced protocol. Participants 2, 4, and 5 received the omissions reinforced protocol.

performance on the non-social stimuli appears to have a stable upward trend, with a sudden decrease in correct responding between 70^{th} and 80^{th} trial.

In participant 2's graph, there appears to be a random response pattern in the amount of correct responses across trials for the social stimuli, which may explain why he did not meet criterion for discrimination. Participant 2's response pattern appears stable around 5 - 6 correct responses to the non-social stimuli.

The most successful at capturing the discrimination was participant 4. He demonstrated a quick and steady trend early on in the task for both social and non-social stimuli. However, his response pattern depicts an unstable trend in the amount of correct responses particularly between the 40th and 60th trials of testing block 1. His performance improved towards the end of block 2 with regard to the social stimuli. There also appears to be a stable upward trend with regard to participant 4's correct responding to the non-social stimuli. This may have contributed to his high to near perfect discrimination ratio.

Participant 5's response pattern to the social stimuli appears random until the 60th trial in which the number of correct response then stabilize around 6 per trial block. The randomness of responding may have contributed to him not meeting criterion for discrimination. Participant 5's pattern of correct responding appears random with respect to the non-social stimuli.

Figure 2 depicts the performance graphs for the typically developing participants. Participant 7 was the only typically developing participant to receive the omissions not reinforced protocol. Participants 8, 9, and 10 received the omissions reinforced protocol.

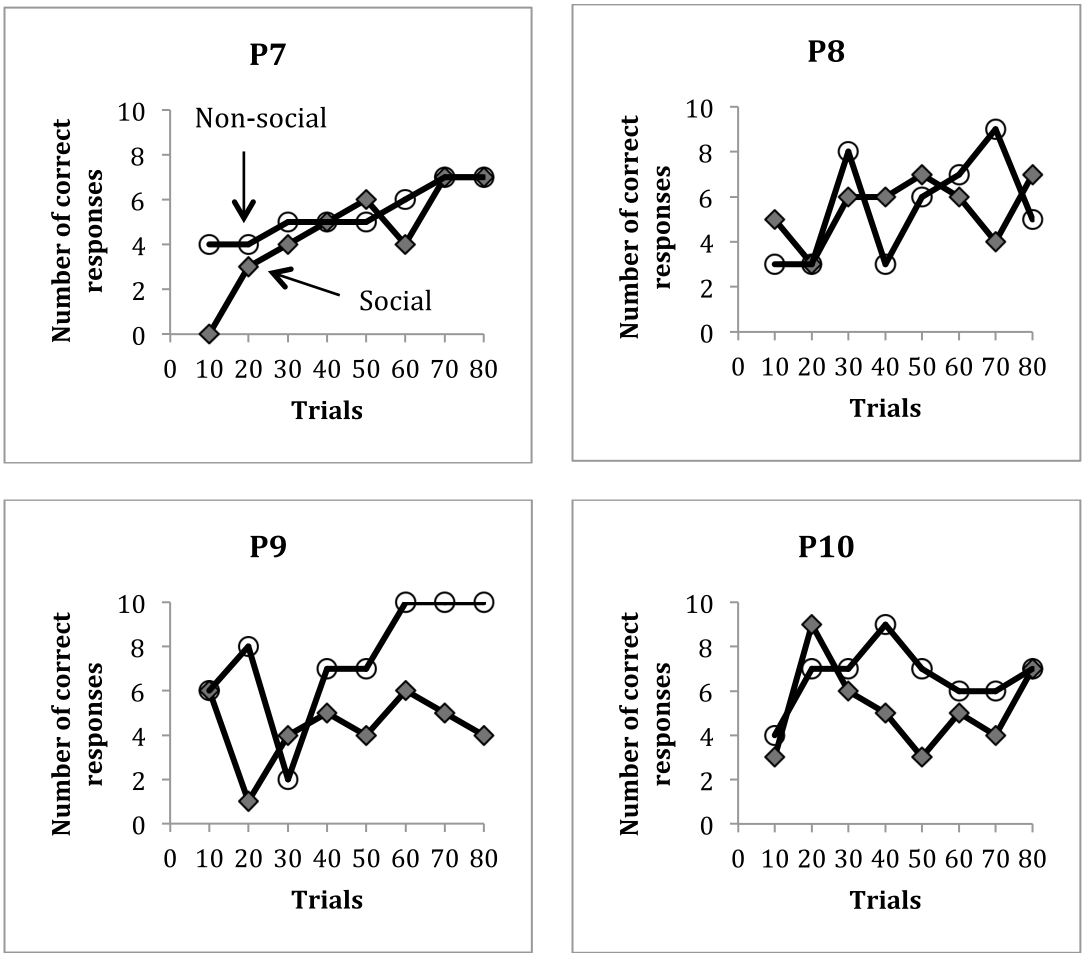

Figure 2. Displays the number of correct responses for both correct button presses and correct omissions on the social stimuli assigned a clear consequence (e.g., neutral faces and happy faces) and on the non-social stimuli assigned a clear consequence (e.g., clear skies and sunny skies) for typically developing participants. Participant 7 received the omissions not reinforced protocol, whereas P8, 9, and 10 received the omissions reinforced protocol.

Regarding the social stimuli, there appears to be an upward trend in the amount of correct responses across trials with a slight decrease at the 60th trial, which may have contributed to participant 7 having a moderate discrimination ratio. Participant 7 (Typically developing) displayed a steady upward trend with regard to the non-social stimuli and toward the end of the task for the social stimuli.

Participant 8's response pattern appears to be random to the social stimuli, which may explain why he did not meet criterion for discrimination. Participant 8's response pattern to the non-social stimuli also appears to be random.

Participant 9's performance on the social stimuli appears to be unstable at the beginning with fluctuations between the 40th and 60th trials. Then there is a decrease toward the 80th trial. With respect to the non-social stimuli, participant 9's response pattern takes a significant decrease at the 30^{th} trial but then recovers at trial 40, then steadily increases. Participant 9 also displayed an upward trend toward the last testing block for the non-social stimuli.

Participant 10's performance regarding the social stimuli appears to increase significantly at the beginning, then after the 20^{th} trial there was a downward trend in the amount of correct responses until the 70^{th} where there is a sudden increase to the 80^{th}. This pattern of responding was considered random and consequently participant 10 did not meet discrimination criterion. Participant 10's response pattern to the non-social stimuli displayed a steady increase in correct responses, then after the 40^{th} trial there was a steady decrease with a slight increase at the 80^{th} trial.

Discussion

The purpose of the present study was to explore the behavioral principles that underlie social skill deficits in ASD by determining the extent to which social stimuli serve as a discriminative stimulus for reinforcement or non-reinforcement as compared to non-social stimuli by using a computerized stimulus control task. It was hypothesized that over successive trials participants with ASD would capture the contingencies around the non-social stimuli more readily than for the social stimuli as indicated by committing more correct responses and fewer errors, and that they would acquire the antecedent-response consequence contingency as indicated by their discrimination index ratio. Typically developing participants would capture the contingencies around the social stimuli more readily than for the non-social stimuli as indicated by committing more correct responses and fewer errors and they would score a moderate to high discrimination index ratio. It was also hypothesized that both participants with ASD and typically developing would commit more errors than correct responses to the ambiguous stimuli and that the discrimination ratios calculated for the ambiguous stimuli would be moderate to low. The results failed to support the identified hypotheses. The majority of participants in both groups displayed little to moderate discrimination both in terms of their discrimination ratios and response patterns. The exceptions were participants 4 (ASD) and 9 (Typically developing). Participant 4 was the most successful at capturing the contingencies over the course of the task and performance was quite strong as indicated by his discrimination ratio and response pattern graph for both social and non-social stimuli. Participant 9 had a moderate ratio, but demonstrated steady improvement across trials particularly for the non-social stimuli.

It was clear that participant performance on the computerized task was not consistent across participants within their respective groups. During sessions, there were a number of noted observations that may explain some of the variability in performance. It was noted that most participants displayed a consistent pattern of responding that interfered with their ability to learn the programmed contingency. For example, participants 1, 3, 7, and 8 had a tendency to press the button that subsequently led to more errors of commission. It is possible that these participants kept pressing the button because it eventually led to receiving the reinforcer. Whereas for participants in the omissions reinforced group, P2 and P5 realized that they could watch the pictures go by on the screen and receive the reinforcer intermittently, thus committing more errors of omission. Therefore, in the absence of specific instruction on or knowledge of how to respond, participants displayed distinctive and repetitive response styles that did not maximize reinforcement. It is possible that the ambiguity introduced by the $S^?$ stimuli (lightning and angry faces) disrupted the process of stimulus control for even the clear, consistently reinforced stimuli.

Furthermore, it was found that if the participant had a consistent pattern of responding- there were more errors (EoO or EoC) on clear and ambiguous stimuli. However, if the participant responded at random (varying their response) then they had a better chance at earning reinforcement with the ambiguous stimuli. The participants with ASD with the exception of participant 4 appeared to respond at random. During the live sessions, participants 7 and 8 (both typically developing) admitted that they were looking for a pattern within the presentation of the stimuli. Additionally, typical participants tended to commit more errors of commission to the happy face stimuli, this may be indicative of the interference that occurs between previous reinforcement history and new learning.

Research on facial processing by Grelotti, Gauthier, and Schultz (2002) pointed out that that typically developing individuals' process human facial expressions through categorization based on emotional state and feature configuration. Individuals with ASD typically display a process that is feature-based, that is they typically focus on parts of the face rather than processing the features as a complete set (Grelotti et al., 2002). This could be the underlying reason why we observed the disparity between participant groups with regard to their patterns of performance. Typical participants were focused on looking for a pattern- categorization, whereas participants with ASD were focusing on individual features which as Grelotti and colleagues (2002) mentioned, could have influenced individuals with ASD to treat each picture as a new stimulus rather than grouping them based on category.

In addition to previously discussed observations, there were several limitations that potentially impacted the results. It is plausible that the goal of the computerized task to simulate real life social contexts at a mid-level complexity may have been too ambitious. There were a few encountered issues when running sessions. It was noticed for several participants that there was ambiguity in the emotions conveyed in the pictures themselves. With regard to the social stimuli, pictures of people with closed mouths were deliberately chosen because research showed that people with ASD tend to focus on the mouth rather than the entire face (Klin et al., 2002). However, it was observed that some participants (both ASD and typically developing) experienced difficulty distinguishing between the neutral and happy faces, and at times between neutral and angry. A few of the neutral face pictures were reported by participants as looking “sleepy” and “sad”.

It was also plausible that the task may have been too difficult for participants due to the inclusion of the ambiguous stimuli category. The ambiguous category was included to mirror that of real-life social contexts in which there are clear antecedents for social interaction and no social interaction, but there are also instances in which it is not quite clear- ambiguous context. The purpose was to look for patterns of response to these ambiguous situations in order to determine if they differ between typically developing children and children with ASD. In this regard, adding the ambiguous category was a strength of the study because it simulated real-life social context. However, the addition of these stimuli may have increased the likelihood that the task was not matched to participants' level of functioning. Participants with ASD were required to have scored at least a Level 3 on the ABLA indicating visual discrimination ability, however, the task on the ABLA is a simpler discrimination in comparison to the computerized task.

Moreover, the discrimination index ratios used to quantify discrimination on the computer task was based on a calculation employed in basic animal research. However, it did not provide an accurate quantification of discrimination especially in comparison to visual inspection of the raw data. The discrimination ratios did not allow us to identify "late discriminators"- individuals who may have captured the contingency towards the end of the computer task, because the ratios characterized overall responding instead of responding across time.

The aim of the present study was not to teach the discrimination between social and non-social stimuli but to explore the range of responding of both individuals with ASD in comparison to typically developing individuals. The implications of the current findings warrant modifications to the current computerized task to better facilitate discrimination. As a result of the study, a number of adjustments to the current computer task have been identified. First, the current computer protocol used 240 different stimuli: 40 pictures for each of the 6 subcategories of stimuli (social: neutral, happy, angry; non-social: clear, sunny, lightning). Use of a smaller set of stimuli such as 10 pictures for each subcategory and repeated exposure to each of the stimuli over successive trials rather than one presentation per picture over a mass amount of different pictures each trial is recommended.

A second recommendation would be to remove the ambiguous stimuli and conduct the study using only the clear consequence stimuli (e.g., happy, sunny, neutral and clear) while making sure to reinforce correct omissions as well as correct button presses. In the present study, the S^+, S^-, and $S^?$ stimuli were all programmed into the two testing blocks, however as a third recommendation present one trial block for the clear consequence stimuli and another testing block for the ambiguous stimuli. Alternatively, only the ambiguous stimuli would be programmed into a computerized task.

Fourth, conduct a picture-sorting task in which participants have to sort the pictures either into a reinforcement pile or a no reinforcement pile. This was piloted on participant 7 and 3, and both participants displayed slightly better performance than on the computer task. It is possible that a history of playing computer games may have contributed to the rapid button pressing seen participants who displayed high EoC rates. Many computer games require individuals to press buttons to advance within the game and this history may have interfered with performance on our computer task. Both participants 3 and 7 displayed a high rate of EoCs due to excessive button pressing. Based on anecdotal report, participant 3 repeatedly stated to himself when pressing the button that “it should work, go faster”.

The listed modifications can provide a basis for future investigation that will further extend on the current findings and provide more insight into the underlying behavioral processes of social discrimination. Another possibility for future research would be to conduct a study that employed the “Reading the Mind in the Eyes” Test by

Baron-Cohen, Jolliffe, Mortimore, and Robertson (1997) to test for antecedent control between social and non-social stimuli. The "Reading the Mind in the Eyes" Test assesses the social sensitivity of adults namely, their ability to place themselves in the mind set of another person (i.e., theory of mind) (Baron-Cohen et al., 1997). In the test, adults with Asperger syndrome or high-functioning autism were shown 25 pictures of the eye-region of various people (male and female) and asked to choose a thought or emotion that best described the picture (Baron-Cohen et al., 1997). The test was revised by Baron-Cohen, Wheelwright, Hill, Raste, and Plumb (2001). A final possibility for future research would be to use simpler pictures such as black and white to reduce the amount of facial features to distinguish from (e.g., color- hair, skin, eye; hair type- straight, curly).

Although the findings of the current study did not support its initial hypotheses, they did provide numerous areas for further investigation of social discrimination skills in individuals with ASD. Addressing the limitations and incorporating the recommendations discussed above, researchers could continue to work towards identifying the underlying behavioral mechanisms that define the social behavioral phenotype in ASD.

References

Adobe Photoshop Elements 10 [Computer software]. San Jose, CA: Adobe Systems Incorporated.

American Psychiatric Association, (2000). Diagnostic and Statistical Manual of Mental Disorders, 4th ed. Text Revision. American Psychiatric Association, Washington, DC.

Anderson, G. M., Scahill, L., McCracken, J. T., McDougle, C. J., Aman, M. G., Tierney, E. L., Arnold, L. E., . . . Vitiello, B. (2007). Effects of short-and long-term risperidone treatment on prolactin levels in children with autism. *Biological Psychiatry*, *61*, 545-550. doi: 10.1016/j.biopsych.2006.02.032

Bailey, A., Phillips, W., & Rutter, M. (1996). Autism: Towards an integration of clinical, genetic, neuropsychological, and neurobiological perspectives. *Journal of Child Psychology and Psychiatry*, *37*, 89-126. doi: 10.1111/j.1469-7610.1994.tb02300.x

Baron-Cohen, S. (1988). Social and pragmatic deficits in autism: Cognitive or affective? *Journal of Autism and Developmental Disorders*, *18*, 379-402. doi:10.1007/BF02212194

Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high-functioning adults with autism or Asperger syndrome. *Journal of Child Psychology and Psychiatry*, *38*, 813-822.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The “Reading the Mind in the Eyes” Test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, *42*, 241-251.

Bolton, P., Macdonald, H., Pickles, A., Rios, P., Goode, S., Crowson, M., Bailey, A., & Rutter, M. (1994). A case-control family history study of autism. *Journal of Child Psychology and Psychiatry*, *35*, 877-900. doi:10.1111/j.14697610.1994.tb02300.x

Campbell, J. M. (2003). Efficacy of behavioral interventions for reducing problem behaviors in persons with autism: A quantitative synthesis of a single-subject research. *Research in Developmental Disabilities*, *24*, 120–138. doi:10.1016/S0891-4222(03)00014-3

Caruso-Anderson, M., Paclawskyj, T. R., Kurek, D., & Hagopian, L. P. (2009, May). Functional behavioral phenotypes. In L. P. Hagopian (Chair), Epidemiological analyses of large databases involving functional analyses and function-based interventions. Symposium conducted at the meeting of the Association of Applied Behavior Analysis International, Phoenix, AZ.

Constantino, J. N., Davis, S. A., Todd, R. D., Schindler, M. K., Gross, M. M., Brophy, S. L., . . . Reich, W. (2003). Validation of a brief quantitative measure of autistic traits: Comparison of the Social Responsiveness Scale with the Autism Diagnostic Interview-Revised. *Journal of Autism and Developmental Disorders*, *33*, 427-433. doi: 10.1023/A:1025014929212

Dawson, G. (2008). Early behavioral intervention, brain plasticity, and the prevention of autism spectrum disorder. *Development and Psychopathology*, *20*, 775-803. doi: 10.1017/S0954579408000370

Dawson, G., Carver, L., Meltzoff, A. N., Panagiotides, H., McPartland, J., & Webb, S. J. (2002). Neural correlates of face and object recognition in young children with autism spectrum disorder, developmental delay, and typical development. *Child Development*, *73*, 700–717. doi: 10.1111/1467-8624.00433

Dawson, G., Webb, S. J., Wijsman, E., Schellenberg, G., Estes, A., Munson, & J., Faja, S.(2005). Neurocognitive and electrophysiological evidence of altered face processing in parents of children with autism: Implications for a model of abnormal development of social brain circuitry in autism. *Development and Psychopathology*, *17*, 679–697. doi: 10.1017/S0954579405050327

DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis*, *29*, 519-533. doi: 10.1901/jaba.1996.29-519.

Dittrich, W. H., & Lea, S. E. G. (1993). Motion as a natural category for pigeons: Generalization and a feature-positive effect. *Journal of the Experimental Analysis of Behavior*, *59*, 115-129.

Dykens, E. M., & Hodapp, R. M. (2007). Three steps toward improving the measurement of behavior in behavioral phenotype research. *Child Adolescent Psychiatric Clinics of North America*, *16*, 617-630. doi: 10.1016/j.chc.2007.02.001

E-Prime (Version 2.0) [Computer software]. Sharpsburg, PA: Psychology Software Tools, Inc.

Filipek, P. A., Accardo, P. J., Baranek, G. T., Cook, E. H., Dawson, G., Gordon, B., . . . Volkmar, F. R. (1999). Screening and diagnosis of autistic spectrum disorders. *Journal of Autism and Developmental Disorders*, *29*, 439-484. doi: 10.1023/A:1021943802493

Folstein, S., & Rutter, M. (1977). Infantile autism: A genetic study of 21 twin pairs. *Journal of Child Psychology and Psychiatry*, *18*, 297-321. doi: 10.1111/j.1469-7610.1977.tb00443.x

Fombonne, E. (2003). Epidemiological Surveys of Autism and Other Pervasive Developmental Disorders: An Update. *Journal of Autism and Developmental Disorders*, *33*, 365-382. doi: 10.1023/A:1025054610557

Frith, U. (1989). Autism: Explaining the enigma. United Kingdom: Blackwell.

Frith, U., & Happe, F. (1994). Autism: Beyond "theory of mind". *Cognition*, *50*, 115-132. doi: 10.1016/0010-0277(94)90024-8

Grelotti, D., Gauthier, I., & Schultz, R. (2002). Social interest and the development of cortical face specialization: What autism teaches us about face processing. *Developmental Psychobiology*, *40*, 213–225. doi: 10.1002/dev.10028

Harms, M. B., Martin, A., & Wallace, G. L. (2010). Facial emotion recognitions in autism spectrum disorders: A review of behavioral and neuroimaging studies. *Neuropsychology Review*, *20*, 290-322.

Herrnstein, R. J., Loveland, D. H., & Cable, C. (1976). Natural concepts in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes*, *2*, 285-302.

Hodapp, R. M., & Dykens, E. M. (1994). Mental retardation's two cultures of behavioral research. *American Journal on Mental Retardation*, *98*, 675-687.

Hodapp, R. M., & Dykens, E. M. (2005). Measuring behavior in genetic disorders of mental retardation. *Mental Retardation and Developmental Disabilities Research Reviews*, *11*, 340-346. doi: 10.1002/mrdd.20087

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis*, *27*, 197-209. doi:10.1901/jaba.1994.27-197

Kennedy, C. H., Caruso, M., & Thompson, T. (2001). Experimental analyses of gene-brain-behavior relations: Some notes of their application. *Journal of Applied Behavior Analysis*, *34*, 539-549. doi: 10.1901/jaba.2001.34-539

Kerr, N., Meyerson, L., & Flora, J. A. (1977). The measurement of motor, visual, and auditory discrimination skills. *Rehabilitation Psychology*, *24* (monograph issue), 95-112.

Klin A, Schultz R, Cohen D. (2000). Theory of mind in action: Developmental perspectives on social neuroscience. In Baron-Cohen, S., Tager-Flusberg, H., Cohen, D., *Understanding Other Minds: Perspectives From Developmental Neuroscience*, 2nd ed. (pp. 357–388). Oxford, UK: Oxford University Press.

Klin, A., Jones, W., Volkmar, F., & Cohen, D. (2002). Defining and quantifying the social phenotype in autism. *American Journal of Psychiatry*, *159*, 895-908. doi: 10.1176/appi.ajp.159.6.895

Klin, A., Lin, D. J., Gorrindo, J., Ramsay, G., & Jones, W. (2009). Two-year-olds with autism orient to non-social contingencies rather than biological motion. *Nature*, *459*, 257-261. doi:10.1038/nature07868

Lehman, E. (Producer), & Nichols, M. (Director). (1966). *Who's Afraid of Virginia Woolf?* [Motion picture]. USA: Warner Brothers Studios.

Lord, C., Schopler, E., & Revicki, D. (1982). Sex differences in autism. *Journal of Autism and Developmental Disorders*, *12*, 317-330. doi: 10.1007/BF01538320

Mace, F. C., & Mauk, J. E. (1995). Bio-behavioral diagnosis and treatment of self-injury. *Mental Retardation and Developmental Disabilities*, *1*, 104-110.

Martin, G. L., & Pear, J. J. (2015). *Behavior modification: What it is and how to do it*, 10th ed. Upper Saddle River, NJ: Pearson.

Matson, J. L., & Wilkins, J. (2007). A critical review of assessment targets and methods for social skills excessed and deficits for children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *1*, 28-37. doi: 10.1016/j.rasd.2006.07.003

McConnell, S. R. (2002). Interventions to facilitate social interaction for young children with autism: Review of available research and recommendations for educational intervention and future research. *Journal of Autism and Developmental Disorders*, *32*, 351-372.

Mitchell, P., & Ropar, D. (2004). Visuo-spatial abilities in autism: A review. *Infant and Child Development*, *13*, 185-198. doi: 10.1002/icd.348

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1986). Defining the social deficits of autism: The contribution of nonverbal communication measures. *Journal of Child Psychology and Psychiatry, 27,* 657-669. doi: 10.1111/j.14697610.1986.tb00190.x

Pickles, A., Bolton, P., Macdonald, H., Bailey, A., Le Couteur, A., Sim, C. H., & Rutter, M. (1995). Latent-class analysis of recurrence risks for complex phenotypes with selection and measurement error: A twin and family history study of autism. *American Journal of Human Genetics*, *57*, 717-726.

Rao, P. A., Beidel, D. C., & Murray, M. J. (2008). Social skills interventions for children with Asperger's syndrome or high-functioning autism: A review and recommendations. *Journal of Autism and Developmental Disorders*, *38*, 353-361. doi:10.1007/s10803-007-0402-4

Ramdoss, S., Machalicek, W., Rispoli, M., Mulloy, A., Lang, R., & O'Reilly, M. (2012). Computer-based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review. *Developmental Neurorehabilitation*, *15*, 119-135. doi: 10.3109/17518423.2011.651655

Reichow, B., & Volkmar, F. R. (2010). Social skills interventions for individuals with autism: Evaluation for evidence-based practices within a best evidence synthesis framework. *Journal of Autism and Developmental Disorders*, *40*, 149–166. doi: 10.1007/s10803-009-0842-0

Rogers, S. (2000). Interventions that facilitate socialization in children with autism. *Journal of Autism and Developmental Disorders*, *30*, 399–409. doi: 10.1023/A:1005543321840

Simmons, D. R., Robertson, A. E., McKay, L. S., Toal, E., McAleer, P., & Pollick, F. E. (2009). Vision in autism spectrum disorders. *Vision Research*, *49*, 2705-2739. doi:10.1016/j.visres.2009.08.005

Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis*, *10*, 349-367. doi: 10.1901/jaba.1977.10-349

Tottenham, N., Tanaka, J., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., Nelson, C. A. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Research*, *168*, 242-249. doi: 10.1016/j.psychres.2008.05.006

Walton, K. M., & Ingersoll, B. R. (2013). Improving social skills in adolescents and adults with autism and severe to profound intellectual disability: A review of the literature. *Journal of Autism and Developmental Disorders*, *43*, 594-615. doi: 10.1007/s10803-012-1601-1

Waterhouse, L., Fein, D., & Modahl, C. (1996). Neurofunctional mechanisms in autism. *Psychological Review*, *103*, 457–489. doi: 10.1037/0033-295X.103.3.457

Weiss, M., & Harris, S. L. (2001). Teaching social skills to people with autism. *Behavior Modification*, *25*, 785-802. doi: 10.1177/0145445501255007

White, S. W., Keonig, K., & Scahill, L. (2007). Social skills development in children with autism spectrum disorders: A review of the intervention research. *Journal of Autism and Developmental Disorders*, *37*, 1858-1868. doi: 10.1007/s10803-006-0320-x