DEVELOPMENT AND PILOT STUDY OF THE CHILDHOOD AUTISM SOCIAL SKILLS ASSESSMENT

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Abstract

Background: Autism Spectrum Disorder (ASD) has two defining deficits: social communication and stereotyped and repetitive behaviour. This pilot study trialled 5 tasks based on current literature to measure the social cognitive skills of children with ASD, titled the Childhood Autism Social Skills Assessment (CASSA). The five tasks were designed to measure performance-based differences in children with ASD using response time and accuracy to compare 13 controls and 12 autism groups. Quantitative differences were found between the children with autism and the neurotypical controls, as well qualitative results which will be used to increase validity and reliability for these tasks in the future.

Methods: The CASSA was administered within a single session. 27 youth aged 6-17 (13 with ASD, 14 Controls) were assessed using the 5 CASSA tasks. Participants' parents completed standardized questionnaires as supplemental information. The CASSA is made up of five sections which are the Emotional Stroop, Navon, Blur into Focus, Theory of Mind, and McGurk tasks. The Emotional Stroop task is based on creating the Stroop Effect using an emotional face with an incongruent emotional word over the bridge of the nose. The Navon task measures reaction time of participant's ability to recognize a target number that may or may not be embedded within a large number made up of small numbers. The Blur-to-focus task requires the participant to identify the emotion displayed on faces (Happy, Sad, Angry or Afraid), that start blurred and gradually come into focus. The CASSA measures Theory of Mind (ToM) development by a series of cartoons depicting the interaction of two children, whose situations become increasingly more complex as the task goes on.

Results and Conclusions: Results indicate that the CASSA may be used as an addition to a clinical assessment battery, specifically using the Navon, Emotional Stroop, and Blur into Focus

tasks which were able to produce statistically significant performance differences between groups. The CASSA has the potential to aid in diagnosis as part of a battery as well as to allow researchers and clinicians to assess social skills through electronic assessment.

Acknowledgements

Thanks for the patience.

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Introduction

1.1 Current Understanding of Autism Spectrum Disorder

The Diagnostic and Statistical Manual of Mental Disorders (DSM 5) identifies that Autism Spectrum Disorder (ASD) is characterized by deficits in general life functioning in two core areas, social communication and restricted and repetitive behaviours (American Psychiatric Association, 2013). Social communication broadly captures the reciprocal exchanges that take place in social-emotional interactions, where both individuals must initiate and respond to maintain an interaction. This broad definition can also include a lack of ability to communicate or understand emotions nonverbally through body language or eye contact. Deficits in the ability to use or recognize non-verbal cues is a hallmark of ASD and includes the misunderstanding of social gestures and displays of facial emotion (American Psychiatric Association, 2013). These deficits may underlie a processing delay observed in children with ASD that often leads to a misidentification of emotions (Spezio, Adolphs, Hurley, & Piven, 2007).

Diagnostically, there must also be demonstrable restrictive, repetitive patterns of behaviours, interests or activities (known as RRBs) (American Psychiatric Association, 2013). A repetitive pattern of behaviour may be expressed as self-stimulating actions through motor movements (E.g. Hand flapping, rocking), or repeated language use (e.g. echolalia, idiosyncratic phrases). Over-focusing on a specific interest known as a circumscribed interest can also satisfy the second criteria of the autism diagnosis (American Psychiatric Association, 2013).

1.1.a. Theories of Autism Spectrum Disorder

There are three main theories proposed to explain the behavioural and social differences displayed in people with ASD; Theory of Mind (ToM), Executive Functioning deficits (EF), and the presence of a Local Processing Bias (LPB). Executive functioning deficits are theorized to account for repetitive and stereotyped behaviours. The deficits in inhibition, planning, and flexibility have also been suggested to underlie the socio-communicative symptoms (Cantio, Jepsen, Madsen, Bilenberg, & White, 2016). A Local Processing Bias (LPB) has been proposed as an alternative explanation for why individuals with autism can have varied performances on tasks that assess attention, global/local processing and ToM tasks (e.g. Sally-Anne Task, Strange Stories Tasks)(Plaisted, O'Riordan, & Baron-Cohen, 1998). Multiple recent studies have provided further evidence of an ASD cohort having comparable abilities to control when the examiner directs the participant with ASD's attention to social or emotional elements of the environment (Hayward et al., 2012; Iarocci, Burack, Shore, Mottron, & Enns, 2006).

1.1.b. Heterogeneity within Autism

The term "spectrum" has been adopted in Autism Spectrum Disorder to reflect the broad range of behaviours that fall under the diagnosis. In the DSM 5 four disorders were collapsed under the broad term of Autism Spectrum Disorder (Further discussion below), to create an umbrella term to encapsulate the variable presentation of symptoms. The highly heterogenous presentation of ASD-related behaviours may not have been fully captured in past studies, leading to the overgeneralization of findings (Bottema-Beutel, Kim, & Crowley, 2019). In a metareview of social functioning correlates comparing children with autism and typical development groups, Bottema-Beutel et al. (2019) found that although studies showed performance differences in social skills that significantly distinguished ASD participants from controls, the effect sizes reported in each study was small (No greater than 0.3). This led the authors to conclude that these studies were affected by the heterogeneity of symptomology for ASD, while emphasizing the need for future studies to use larger samples. Bottema-Beutal et al. (2019) also commented on the potential for our current theories are based upon studies that have small effect sizes and small sample groups (Bottema-Beutel et al., 2019). Finally language impairments, and other cognitive disabilities are often comorbid with ASD, however not all children with ASD show global language impairments, complicating the findings from any study (American Psychiatric Association, 2013). It is suggested that these overarching explanations for the different behaviours of children with autism are too broad and fail to encompass the considerable heterogeneity of this disorder. As a consequence, studies with broad behavioural inclusion may carry too many behaviours to offer a more nuanced understanding of ASD (Georgiades et al., 2013).

1.2 Assessment of Autism Spectrum Disorder

In the DSM 5, the ASD diagnostic category now encompasses four developmental disorders previously held as separable in the DSM IV as a result of scientific consensus (American Psychiatric Association, 2013). The four disorders from the DSM-IV were: Autism, pervasive developmental disorder not otherwise specified, childhood disintegrative disorder, and Asperger's disorder (American Psychiatric Association, 2013). These disorders are now collected under one umbrella term (ASD) that captures varying degrees of severity of symptomology pertaining to Autism. A diagnosis of ASD is confirmed when the symptoms of reduced social communication and repetitive patterns of behaviour are observed to significantly impact the child's daily functioning (American Psychiatric Association, 2013). Currently there are a number of tools for assessing Autism Spectrum Disorder, many of which involve paper and pencil checklists or the interview of a parent or caregiver by an experienced clinician. In early childhood there should be regular visits with a doctor, and these can help track developmental markers. To assess delays in development there are a number of screening tools recommended by the American Academy of Paediatrics (AAP) such as the Ages and Stages Questionnaires (ASQ), Communication and Symbolic Behaviour Scales (CSBS), Parents' Evaluation of Developmental Status (PEDS), Modified Checklist for Autism in Toddlers (MCHAT) or the Screening tool for Autism in Toddlers and Young Children (STAT) (Committee on Children and Disabilities, American Academy of Pediatrics, 2001). Given sufficient indicators of ASD psychopathology the child may then be referred a specialist in developmental and behavioural paediatrics. The specialist has multiple assessment tools such as the Autism Diagnostic Interview-Revised (ADI-R), Autism Diagnostic Observation Schedule (ADOS), Childhood Autism Rating Scale (CARS) or the Gilliam Autism Rating Scale (GARS-2) (Committee on Children and Disabilities, American Academy of Pediatrics, 2001).

This paper will give a brief review of the ADI-R and the ADOS as they are the gold standard and as such, are the most commonly used tools used to formulate an ASD diagnosis. These tools were developed to be used together to assess ASD symptoms and can create a reliable clinical diagnosis of Autism (Tanguay, 2000). The ADI-R is a semi-structured interview with a parent, guardian or Person Most Knowledgeable (PMK) who can provide details of the child's developmental milestones, current quality of social interactions, and the presence of repetitive behaviours (Tadevosyan-Leyfer et al., 2003). It can take 2-3 hours to complete the assessment using 111 questions and relies on a trained interviewer who scores each answer on a severity score ranging from 0-3 (3 being most severe) (Le Couteur, Haden, Hammal, & McConachie, 2008). The ADI-R alone is not sufficient for a diagnosis of ASD but may be used to refer the child for more in-depth analysis using tools such as the ADOS. The ADOS is a semi-structured assessment testing for social interaction, communication and play between the examiner and child (Lord, Rutter, et al., 2012). Administration involves the selection of one of four different modules according to the child's developmental level and language capability, and ranging from no expressive vocabulary to verbal fluency. The examiner must make a choice when beginning the assessment about which module is appropriate for the child. Each module takes approximately 30-45 minutes and is able to collect information on language skills, social behaviour and communication, and repetitive behaviours (Le Couteur et al., 2008). The ADI-R and ADOS together gather developmental histories, social and behavioural information from multiple sources to form a valid clinical diagnosis of ASD (Tanguay, 2000; Committee on Children and Disabilities, American Academy of Pediatrics, 2001).

1.3 Computer Based Assessments

Electronic assessments have been emerging in recent years with the increased accessibility to technology around the world (Chen, Wang, Zhang, Wang, & Liu, 2019). There are multiple advantages to using a computer-based assessment for researchers and health care workers. The issues of transporting completed assessments while keeping the records secure is simplified through electronic assessments. The results can be encrypted immediately and can be sent online to any other secure server to be used by the treatment team. Standard assessments rely on large amounts of paper to be recorded on and analysed and then stored for a number of years. This creates multiple steps to gather and access the information that the researcher or clinician has collected. Currently there is an interest in personalized medicine and computer assessments may be one avenue to automate and prescribe individual treatment regimens reflective of the varying degrees of symptom severity.

A recent pilot study found that 130 software programs aimed at assessing or treating individuals with autism have been developed from 1990 to 2017 (Chen et al., 2019). Standard paper and pencil assessment tools used to screen children for developmental delays often involve observational recording, behavioural scoring, tallying responses, conversion to standard scale scores and further interpretation, all of which necessitate greater levels of psychometric training than administering computer-based programs. Children with ASD respond well to computer-based programs as they do not require task shifting, or social pressures and interactions (Wright et al., 2008). Chen et al. (2019) used object recognition from a character's perspective to assess high-functioning children with autism compared to age-matched typically developing controls. Although completion rates were lower for the autism group there were significant performance-based differences between groups, demonstrating the potential of computer-based assessments for ASD (Chen et al., 2019).

Currently in autism research there is a disagreement as to which assessments are detailed enough for diagnostic purposes. There are shorter tests such as the ADI-R which covers the history of the child through a survey while on the other end of the spectrum the ADOS is a comprehensive semi-structured interview with the child and caretaker. As a result of the heterogenetic nature of ASD some children may meet criteria through the ADI-R alone while others may require more comprehensive testing. There is a significant lack of simple, efficient, and accurate tasks to test and retest the ASD symptom profiles of participants. Current assessment tools are often complex, time-consuming and require clinical experience to administer. In particular to assess the social functioning of the child may be a lengthy and involved process involving multiple assessments (Committee on Children and Disabilities, American Academy of Pediatrics, 2001).

1.4 Development of the CASSA

The Childhood Autism Social Skills Assessment (CASSA) was created in partnership with Multi-Health Systems (MHS) and aims to assess the strengths and weaknesses in social skills in children with autism using performance-based differences when contrasted with typically developing controls. The Childhood Autism Social Skills Assessment (CASSA) is a tool that requires minimal training to complete an assessment of social skills in ASD. This allows the CASSA to be used by a broad group of professionals, including teachers, healthcare workers, and guidance counsellors within the school system. This tool has the potential to create a more extensive profile of social skills, aiding in treatment selection, as well as providing researchers a tool for measuring social skills before and after an intervention.

Using the CASSA we can attempt to understand the strengths and weaknesses of the social communication skills of a child with Autism by assessing the mechanics that underlie complex skills. Based on current literature five tasks were designed to measure performance-based differences in children with ASD using response time and accuracy to compare groups. It is made up of five modules which are the Navon, Theory of Mind, Emotional Stroop, Blur into Focus, and McGurk tasks. The Navon task measures response selection and reaction time when a participant is asked to discern visual information at the global or local level. The Emotional Stroop task is based on creating the Stroop Effect using emotional faces with an incongruent or congruent emotional word over the bridge of the nose. The Blur-to-focus task requires the participant to identify the emotion displayed on dynamically changing faces (Happy, Sad, Angry or Afraid), that begin as blurred images and gradually come into focus. The CASSA measures Theory of Mind (ToM) development by a series of cartoon vignettes followed by questions that require various levels of theory of mind. Finally, the McGurk Task examines the cross-modal integration of visual lip movements with vocal speech utterances, such that the presentation of videos conveying incongruent audio-visual channels leads to the formation of a combined percept in neurotypical controls and a failure by children with autism to integrate the auditory with the visual (Zhang et al., 2019).

1.5 Theory of Mind Task

Theory of Mind (ToM) is the ability to perceive someone else's intentions, beliefs, or desires, and is critical for understanding relevant day-to-day social information (Baron-Cohen, Leslie, & Frith, 1985; Senju, 2012). In neurotypically developing children, TOM ability fully matures at an average age of 5 years old as reported by Frith, C., & Frith, U. (2005). In the first study exploring Theory of Mind reported in Cognition (Wimmer & Perner, 1983), 20% of children with autism were able to pass the Sally-Ann task. In 1989 Baron-Cohen demonstrated that although one fifth of children with Autism passed the Sally-Ann task, all failed to pass a second-order theory of mind task (Perner & Wimmer, 1985; Perner et al., 1989).

1.5.a. Current Assessments of Theory of Mind

Wimmer and Perner (1983) started testing ToM through false belief tasks. They created the Sally and Anne task, where participants watch an experimenter create different social scenarios with two dolls named Sally and Anne (Wimmer & Perner, 1983). In First-Order ToM, the participant is asked to take on the perspective of one actor. To measure First order ToM Sally puts an object in location A, which is occluded from view (e.g. a ball under an overturned cup), then Anne leaves the room. Once Anne has left, Sally now puts the object in location B (a different overturned cup, so the ball remains hidden). Anne returns to the room and the participant is asked where Anne will look for the object. The child demonstrates a developed ToM if they say that Anne will look in location A, because that answer suggests that the participant understands Anne has a belief that is separate from what the child knows (Wimmer & Perner, 1983). To measure Second-Order ToM an experimenter creates a situation where the child is asked to identify where Sally thinks Anne will look, even when Ann has privately seen where the object has been moved. This requires the child to understand that Sally doesn't know Anne's knowledge and therefore Sally will have a false belief about Anne.

Happe (1994) created the Strange Stories Task (SST) in an effort to elucidate why individuals with autism, who regularly have uneven intelligence profiles, were occasionally able to complete ToM tasks and were indistinguishable from typically developing controls. ToM abilities were tested using implied context in 24 verbal vignettes, as the answers to questions related to non-linear statements. Happe (1994) had two groups of people with autism, 21 "passers" (those who passed other ToM tests) and 30 "failers". She theorized that a score on the Weschler Comprehension subtest would be a strong predictor of the success or failure during the SST. This concept of comprehension and language skills involvement in the development of ToM has remained valid in the present-day literature. In 1999 Jolliffe et. al created the Strange Stories Film Task (SSFT) based on the paradigm of verbal vignettes and context based questions created by Happe (Jolliffe, Jolliffe, Baron-Cohen, & Baron-Cohen, 1999; Kaland et al., 2005; Murray et al., 2017). The refinement of the assessment to rely less on highly developed language skills as in the original SST, allows for the task to be administered to a wider variance of people with autism. Lastly Baron-Cohen et al. (2001) created another assessment of TOM named Reading the Mind in the Eyes Task, where the participant was asked to match mental state words with static pictures of the eye region of the face (Baron-Cohen et al., 2001; Livingston et al., 2019). The studies described above represent a small selection of current Theory of Mind assessments that are being used to elucidate the social impairments of individuals with autism.

1.5.b. Theory of Mind Task in the CASSA

In the CASSA the Theory of Mind Task (ToM Task) assesses participants using three levels of complexity that together create a composite ToM measure. The most rudimentary level is perspective taking. The second level is first order ToM, and the third level is second order ToM. Perspective taking is the ability to understand that individual actors will have different views, and different information available as a function of their position. The CASSA uses two scenarios involving objects on either side of a wall that can be viewed or are obscured from view for two actors to measure perspective taking. First-order ToM is the ability to understand that another person can have thoughts, beliefs and feelings that differ from one's own. There are four trials of cartoons displaying two children going through different false belief scenarios. The child is asked what false belief the first actor has in relation to the location of an object. Second-Order ToM is the ability to understand that one actor can hold a contradictory belief or understanding to another actor's beliefs separate from the subject. This has two trials of cartoons where the participant is challenged to hold and report the multiple false beliefs that each actor may have through the videos.

1.5.c. Predictions within this Study

In accordance with Frith et al. (1989) we predict that on tests of perspective-taking, both groups will complete the tasks without any error. This is a necessary baseline to establish before continuing with the next task. The second phase will assess first order ToM and we predict that the children with ASD will make more mistakes than the typically developing control group. The third phase will test second order ToM and we expect both group's accuracy will decline due to the complexity of the task but that the ASD group will make more errors.

1.6 Global / Local Perception; The NAVON Task

Multiple studies differentiating TD controls and ASD individual's performance of visual-spatial abilities, commonly use the Navon Task (Navon, 1977). The Navon task requires individuals to look at large letters (Global) made up of smaller letters (Local) (Appendix F). The letters are presented rapidly, and the participant is directed to focus on letters at a particular level (Global/Local) and detect the occurrence of a target letter. The stimuli Navon used were the letters "S" and "H", and the letter stimuli could be consistent (a big "s" made of small "Ss") or conflicting (a big "S' made of little "Hs"). Local interference is observed when TD participants show delayed reaction times and decreased accuracy when directed to detect a certain target letter at the global level, and the stimulus has a locally incongruent letter. In contrast, Global interference is observed when the participant is directed to attend to the local level, and an incongruent letter is found at the global level which causes interference and results in slowed responses and errors (Navon, 1977). The evidence suggests that typically developed controls will demonstrate increased response times and decreased accuracy when asked to process stimuli at the local level when there is global interference. For children with ASD however, they appear more sensitive to the local interference effect when compared to controls. TD children typically make the most errors when visual targets appear at the local level (where the global image may conflict with the target), whereas children with autism make more errors when the target appears at the global level (Plaisted, Swettenham, & Rees, 1999). These results are linked to weak central coherence in children with autism and deficits in creating holistic images or a gestalt, and a preference for local processing (Bernardino et al., 2012).

1.6.a. Autism Spectrum Disorder and Processing Biases

The Weak Central Coherence theory (WCC) describes the difficulties expressed by individuals with ASD to assess a coherent image made up of parts. Frith (2005) hypothesized that the typically developed adult has the ability to synthesize small pieces of visual information to form one large image (Frith, 2005). This ability to view complex stimuli as a simple image aids in an individual's processing of large amounts of information quickly. This suggests that individuals with autism may focus on local rather than global aspects of stimuli (Happé & Frith, 2006). Happe (2008) argued that the most important factor when considering the perceptual processing deficits in autism is not the unique local processing but more so the lack of or reduced integrative processing (failing to assemble a global holistic whole) (Happé & Booth, 2008). This creates a tendency to focus on the small or local parts that make up the whole image as it seems to be easier for ASD participants. This preference for the local stimuli within ASD may explain their superior performance when shown stimuli involving figure-ground images requiring the participant to identify small component parts of the whole (Plaisted et al., 1999). The deficit in assembling a holistic image made up of many parts, may also play a role in the dysfunctional emotional recognition ability commonly found within the ASD population (Wang, Mottron et al., 2007). Therefore, the Navon task is helpful when assembling a hierarchical battery to test the social emotional processing abilities of ASD children.

1.6.b. Navon Task within the CASSA

The CASSA utilizes the Navon task to measure autistic children's local and global processing as a precursor to social processing. There are the three separate conditions of attention: selective attention Global level, selective attention Local level and Divided Attention (the target can an appear on either level). Divided attention element allows researchers to investigate differences in reaction time and accuracy for children with ASD when they no longer have a prescribed target level. Here, a more rapid reaction time may indicate the level at which the child shows a processing precedence.

1.6.c. Predictions within this Study

Children with Autism are predicted to have increased reaction time and error rates during the selective attention global incongruent condition (where the target is on the global level with an incongruent local image), as a result of their preference for a local image and the inaccuracies when the target appears on the global level. If a child struggles to identify when a target appears on the global level because of an incongruent local image, it may be supportive of the Weak Central Coherence theory while also being a possible marker for other difficulties with facial emotion recognition. During the divided attention condition we predict a significant increase in error rates and reaction time during trials when the target appears on the global level (regardless of congruency).

1.7 The Blur Task - Facial Emotion Processing

People with ASD show irregularities in facial processing, for both emotion expressions and identity recognition (Bate & Bennetts, 2015; Klin et al., 1999; Kuusikko et al., 2009). Klin et al. (1999) measured emotion recognition with facial images under two conditions; upright and inverted (stimuli presented upside down). Neurotypical controls process faces holistically, as was demonstrated when that processing was interrupted by presenting the faces upside down and led to more errors in emotion and identity recognition. In contrast, compared to controls, individuals with ASD made more errors in both emotion and identity recognition of the faces, regardless of orientation. Klin et al. (2002) provided further evidence of differences between those with ASD and typically developing controls in facial emotional information gathering tasks. When children with ASD were compared to controls, they looked at the mouth three times longer while there was a significant reduction in fixation time on the eye region during social contexts. When surveyed, those with ASD who focused longer on the mouth reported significantly higher social adjustment scores when compared to the ASD group that had no facial feature preference (Klin et al., 2002). This may provide insight into the heuristics that older individuals with autism develop over time to navigate their social worlds. The lack holistic facial processing as well as the unusual focus on different part of the face for information allow for the creation of a performance-based task that measures accuracy and response time when children with autism are given limited facial feature information.

1.7.a. The Blur into Focus Task in the Childhood Autism and Social Skills Assessment

The purpose of the Blur into Focus task is to examine facial emotional information processing abilities of children with ASD when shown different elements of a face. The Blur into

Focus Task consists of videos with three focus conditions (Whole face, eyes first, mouth first), with each condition displaying four emotion conditions (happy, sad, angry, and afraid). Each condition starts with the entire face blurred and then face comes into focus as the video plays out. In the whole face condition, the whole stimulus gradually come all at once. The eyes first condition has the eye region coming into focus more rapidly than the rest of the face. In the mouth first condition, the mouth region resolves more quickly than the rest of the face. The participant is asked to stop the unblurring video as soon as they recognize the emotion displayed and then they are then prompted to select one of four emotions (happy, sad, angry, and afraid). Total response time and accuracy of emotion choice are collected across trials per emotion and blur category. The Blur into Focus task may allow insight into whether a population with autism can gain facial emotional information at the same speed and with similar accuracy from the eyes, mouth or entire face. Previous work has shown that children with autism can be averse to the eye region and those that do focus on the mouth region report significantly better social interactions than their peers (Dawson & Watling, 2000; Klin et al., 1999)

1.7.b. Predictions within this Study

We expect that children with autism will be significantly slower and make more errors during the eyes-first unblurring condition. Klin (1999) showed that children with autism were three times as likely to look at the mouth region for facial emotion information. This may translate to faster and more accurate responses from our ASD group during the mouth-first unblurring condition. During the whole face unblurring condition we predict our control group to be quicker and more accurate than our ASD group. The neurotypically developing controls are expected to make the most errors during the anger emotion condition and the mouth first condition (Ashwin, Wheelwright, and Baron-Cohen, 2006).

1.8 Emotional Stroop Task

The Stroop effect is named after its' discoverer, John Ridley Stroop. He hypothesized that reading is a rapid process that is highly automatic. In his experiment participants saw a list of words in printed in different colours of ink and were required to name the colour of the ink of each word. The printed words were colour names (eg. red) and the ink they were printed in could either be congruent with the word label (the word "red" written in red) or incongruent (the word "red" in blue ink) (Stroop, 1935). As reading words is a rapid automatic process, the word text information resulted in a response conflict or an interference effect when the participants were required to name the ink colour of stimuli, and the word and the colour did not match (incongruent). This was observed as a delay in response time or increase in errors which was self-described as the Stroop effect (Stroop, 1935).

Etkin et al (2006) developed a variation on the Stroop, the Emotional Stroop task to explore emotion processing and the capacity to resolve emotional conflict. Instead of the conventional colour-word pairings, Etkin's emotional stroop task presents faces conveying different emotions and the word labels of those emotions. In these stimuli the emotional word is written across the face just below the eyes, and the stimuli can be consistent (e.g. happy face with "happy" written across it) or incongruent (e.g. happy face with the word "sad" written across it). Incongruent stimuli produce response conflict as a result of an incompatibility between task-relevant (face emotion) and task-irrelevant (emotion words) emotional dimensions. When a face was incongruent with the word there was a time delay because of the automatic processing of the word and the interference of this information with the labelling of the facial emotion (Etkin et al., 2006).

1.8.a. Autism Spectrum Disorder Group Performance on the Emotional Stroop Task

Ashwin, Wheelwright, and Baron-Cohen (2006) used the Emotional Stroop task to compare typically developing controls and individuals with autism. Their version of the Emotional Stroop involved face and object stimuli that were shaded in different colours and asked that subjects name the colour of neutral or angry faces and objects like chairs. Neurotypically-developed controls showed slower responses on trials with male angry faces. Ashwin et al. (2006) hypothesized that the delay in processing was related to social threat (angry faces) capturing attention when compared with a neutral face (Ashwin, Wheelwright, and Baron-Cohen, 2006). The participants with autism, in contrast, demonstrated processing delays when comparing any emotional face to non-social objects (Ashwin, Wheelwright, and Baron-Cohen, 2006).

1.8.b. The Emotional Stroop Task within the Childhood Autism and Social Skills Assessment

The Emotional Stroop Task is made up of a unique battery of children faces with an emotion word overlay across the center of the face. The use of children's faces sets this battery apart from previous work that has made use of face image batteries constructed from adult faces (Etkin et al., 2016; Ashwin, Wheelwright, and Baron-Cohen, 2006). This makes the current Emotional Stroop Task a more ecologically valid tool for investigating between group differences using emotion recognition accuracy and reaction time in children.

1.8.c. Predictions within this Study

Based on previous studies we predict that children with autism will have faster reaction times during each condition but having significantly more errors when compared to neurotypically developing controls (Worsham, Gray, Larson, & South, 2015).

1.9 Cross-modal Integration of Auditory and Visual Social Emotional Information

The McGurk effect is an illusion involving our integration of the visual and auditory information available in the perception of speech production. It involves a manipulation of the visual percept of oral movements and auditory speech sounds. The illusion is created when a person is filmed reciting a set of syllables, typically "ba", "da" or "ga" and then the audio for one speech sound is swapped out and replaced with a different syllable sound. As a result, the movement of the lips seen visually does not match the sound presented and when the two stimuli are combined, they are perceived as a novel combined percept (McGurk & Macdonald, 1976).

1.9.a. Predictions within this Study

Children with ASD may not experience the McGurk effect because they may not focus on the same facial features that neurotypical controls. Eye tracking research has demonstrated that when children with ASD watch a video of a person speaking, they look less at the face compared to controls (Irwin et al., 2011), as well as the facial features such as the eyes, and mouth (Ami Klin, Jones, Schultz, Volkmar, & Cohen, 2002). By failing to integrate the auditory with the visual ASD children may rely more heavily on the auditory sensory modality and fail to experience the illusion. During the McGurk Effect trials, we expect the children with autism to select the auditory sounds of "Ba" rather than demonstrating the McGurk Effect.

1.10 Scope of the Current Study

The CASSA has been created with the intent of being part of an assessment battery for children with suspected features of Autism Spectrum Disorder. The CASSA was designed for a younger user, having child friendly instructions, and using child faces for emotion labelling stimuli. The use of performance-based differences between neurotypical and ASD children identified in the literature may help to better understand some component elements of a child's social skills abilities. The Navon Task assesses visual perception and attention. This ability to discern both a unified whole and its elements is critical to assess before examining the more complex mechanisms involved in emotion recognition and the processing of details in the complex social environment. The Emotional Stroop involves attention, inhibition, and facial emotional information identification. In addition, emotion recognition is built on top of social attention and is measured through the Blur-to-Focus. This task requires users to answer as quickly as possible as an emotional face becomes clearer as time passes combining demands for attention to information available from particular regions of the face and emotion recognition within a single task. Finally, the hierarchal task structure of the CASSA finishes with an investigation of a well-established area of deficit in ASD, Theory of Mind. ToM involves an awareness that others can have intentions, beliefs, or desires that differ from one's own and affords a fuller understanding of the actions of people in the social world. Here we report our experience in designing, implementing and piloting these measures aimed at creating an accurate representation of performance-based differences between children with autism and neurotypical controls.

METHODS

2.1 Ethics

Research ethics approval was obtained from the McMaster Research Ethics Board, and all participants gave informed consent/assent prior to participation. Participants were compensated for participation and parking expenses.

2.2 Participants

Participants consisted of 27 children and youth (Control = 11 males, 3 females: ASD = 12 males 1 female) see Table 3. for participant demographics. An independent samples t-test found a significant difference in age between the two groups ($t(25) = -2.232$, $p=.035$). The participants were recruited through the Woodview Treatment Centre for Autism and McMaster University's network of physicians both at St. Joseph Healthcare Hamilton and Chedoke Hospital. The remainder of participants were recruited through print flyers, or through referrals by colleagues (See Appendix C). Participants were required to be verbal and able to comprehend English.

Characteristic	**Total (n=14)**
Mean age (years)	12.642 (± 3.433)
Male : Female (%)	79 : 21

Table 1. Control Demographics.

Characteristic	**Total (n=13)**
Mean age (years)	9.23 (± 2.841)
Male : Female (%)	92 : 8

Table 2. Autism Spectrum Disorder Participant Demographics.

2.3 Measures

The coding to create these tasks was done using software based on python code named Psychopy. Jonathan Peirce created the tool to assist researchers interested in authoring simple psychological experiments. There are two ways to program using Psychopy: 1. User Guided Interface, where there are simple click and drag options; 2. Using python programming language to create the code, line by line. While the first method is faster for generating a basic experiment, the second method permits greater control and flexibility for task design. The experimental data output from Psychopy generates a spreadsheet including participant number, responses given, correct answer, and reaction time. Psychopy requires the user to create a master spreadsheet with the computer pathways linking the software to stimuli (images, videos or text). This spreadsheet must also include the correct responses for trials allowing the software to score answers as correct or incorrect. Generally, we coded for the stimulus presentation to be randomized and set parameter limits on the number of trials in each section of each task.

2.3.a. Theory of Mind Task

Eight cartoon videos were generated to test a range of Theory of Mind (ToM) abilities. The software program Hype 3 (Tumult Inc, San Francisco) was used to build the animations while the narration was provided by a lab member. The ToM task is made up of three distinct categories that build upon the skills necessary to complete the task before, starting from perspective taking through to second order ToM. Instructions were provided for the examiner at the beginning of the task in slides that could be read out-loud to the participant, explaining the upcoming games, the characters involved, and how they should enter their response to the prompts. There are two perspective-taking videos in which two cartoon figures (named Sally and Andrew) stand on either side of a wall. Two objects enter the room on opposite sides of the wall, so that each character can only see one object. After the video finishes the participant is asked what each character can see, setting a baseline of basic perspective taking-abilities. The following video shows a character (Sally) hiding eggs, removing them from an egg carton and placing them into a pot. A chef comes into the room and the participant is asked where the chef will look for his eggs. This requires the child to demonstrate an ability to infer from the situation that eggs are normally in cartons not a pot.

The following two videos test the first order ToM ability of the participants. The first video shows a character, Andrew, place an object in location A (under a blue cup). Andrew then leaves the room, meanwhile Sally (the second character) puts the object in location B. The participant is asked where Andrew will look for the object when he returns. The next scenario has Sally visiting a farm where Andrew is working with a zebra named JimJam. Sally watches while Andrew enters a barn with the zebra, losing visual contact with her (Figure 1). When Andrew washes the zebra, he discovers that JimJam is in fact a white horse. He brings this clean horse out to a pasture and stands beside Sally. The participant is asked where Sally will look for JimJam, in the barn or in the field.

The second-order ToM videos follow the same patterns the participant previously saw in the first-order ToM cartoons with one key difference. In the first scenario Andrew leaves the room but this time he can still see what Sally does with the ball. The participant is asked where Sally thinks Andrew will look for his toy. This requires the ability to take the perspective of Sally who is unaware of Andrew's hidden knowledge. The final second order ToM video involves a similar scenario with JimJam the Zebra and the barn. This time when Andrew leads JimJam into the barn Sally uses binoculars to watch from afar. The child is asked where Andrew thinks Sally will look for JimJam, which would demonstrate an ability to understand Andrew's lack of knowledge regarding what Sally gleaned through the binoculars. This entire ToM task takes approximately 8 minutes to complete.

2.3.b. Navon Task

The Navon task consists of large numbers that are made up of smaller numbers. Across a series of trials, the child is instructed to focus on either the small numbers (Local) or the large numbers (Global). This task was constructed using stimuli similar to those employed by Navon (1977). Our task was comprised of three distinct sections; selective attention global, selective attention local and divided attention. Each section was made up of thirty trials, lasting approximately two to four minutes, with a total running time for the task of approximately ten minutes. Each section used the same stimuli set, which consisted of a large 3 made up of small 3's, a large 3 made up of small 6's, a large 6 made up of small 6's and a large 6 made up of small 3's (Appendix F) . In each attention condition, the stimuli were presented randomly for 30 trials. Output from Psychopy yielded a spreadsheet for each participant with labels for the trial number, response selected, correct response, stimulus shown, and response time. At the beginning of the task, and at the transition to each new test condition the child was given clear instructions. To make the testing more child-friendly, instructions were bright and colourful. The Navon task instruction slides involved the following: Show the child an example stimuli, use a cartoon character to point out the large and small objects that create the picture, ask the child to use the buttons highlighted to distinguish whether they see the target number or not (practice). This procedure helped confirm that the child had understood the instructions. Instructions could be repeated if the child failed to demonstrate an understanding. The instructions in the CASSA were set to change slides when the examiner pushes the spacebar, while the stimulus changes when the child submits an answer using the left option key or the right command button. A keyboard overlay that obscured non-task related keyboard keys allowed the examiner to quickly and easily identify the appropriate buttons for use by the child.

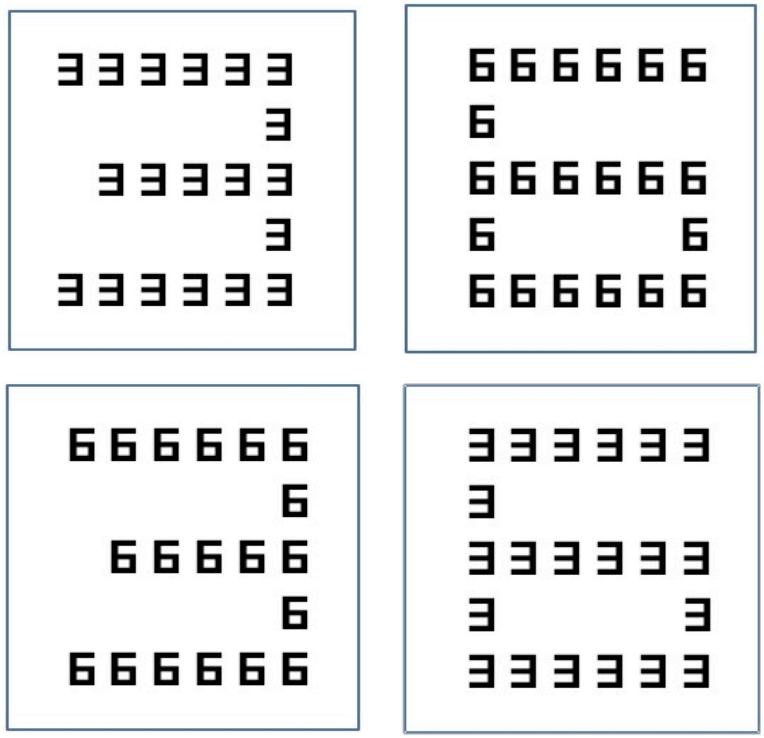

Figure 1. *Navon Stimuli used in the CASSA.*

2.3.c. Blur into Focus Emotional Facial Processing Task

The Blur into Focus emotional facial processing task asks participants to identify facial emotions in blurred faces that gradually become clear. There are four potential emotions that the faces could show: sad, happy, angry, and afraid. The videos were created using stimuli from Shutterstock (a privately-owned website with generic pictures of actors) and piloted in a small sample of University students (n-15?) to confirm that the pictures of children were displaying a clearly recognizable emotion. The faces were centred and stretched to match a standard size so as not to allow participants to make predictive answers during the blur phase of the videos based on the differences of head size of the stimuli. As the video plays, the image comes into focus and the child is asked to identify the emotion seen as soon as possible. There are three unblurring conditions; one in which the eye region resolves at a faster rate than the rest of the face (Eye First) (Figure 4) ; another where the mouth region becomes clearer first (Mouth First) (Figure 5); and a third condition where the whole face resolves at the same rate (Whole Face) (Figure 6). Each of the unblurring videos is eight seconds in length and the child was instructed to press a space bar to stop the video at any time once they knew what emotions the stimuli are displaying. Responses were collected via a selection screen that appears when the video was stopped. There were one hundred twenty stimuli, split up into four parts, with each section including ten of each emotion (Happy, Sad, Angry and Afraid) in a randomized order. The facial emotional processing task took 10-20 minutes to complete, depending on the reaction time and focus / effort of the child.

2.3.d. Emotional Stroop Task

We generated our own child facial emotion picture set, so that our face stimuli would more closely match the ages of the peer group of our study sample. To do this, faces depicting the emotions happy, sad, angry and afraid were selected from the Shutterstock website, with the criteria of being within the age range of 4-16 years, photographed in full face, and of varied sex and race. The pictures included the face and chest of each individual and as a result the faces were cropped from the original, and isolated and put on neutral background (grey for the purpose of this study) (Figure 7). The location of the face in the image frame was held constant by resizing the face image and fixing the horizontal position of the face such that the eyes of each face appeared in the same location across all of the faces in the battery. The four emotional labels were Happy, Sad, Angry and Afraid. These labels were selected with consideration of reading level, word frequency, common usage during childhood and character length. Three stimulus sets were generated; Word only (20 Words), Faces Only (20 Faces), and Stroop stimuli (Words and Faces) (20 congruent, 20 incongruent) (Figure 8). The Stroop stimuli were balanced in terms of emotion types (5 stimuli per emotion X face emotion, per stimulus set).

With 4 emotion labels, response selection using keyboard responses was considered too difficult for our study group. The working memory and spatial attention demands could be sources of confound. As a consequence, responses were collected verbally. In order to do this, each trial began with the production of an audible "beep". Trials were recorded and later analysed using the software Audacity. The time lag between stimulus onset (beep) and the subject verbal response can be visualized in a waveform using this software and millisecond timing recorded (Figure 9). To establish that participants could accurately identify the four facial emotions, and could rapidly read the word labels, we included two baseline testing phases. The first (Words Only) asks the participant to read words that flash on the screen for 250 milliseconds, establishing the baseline requirements of automatic processing of the emotion words. The second baseline task (Faces Only) asked the participant to view faces shown for 250 millisecond and to identify the emotion presented. These two baseline phases also provided the opportunity to discuss the task with the child and if needed, remind the participant of the goals of the task. The final stimuli (Stroop) set had an emotional word label printed across the bridge of the nose just below the eyes of a face. The emotion in the face can match the emotional label (e.g. a happy face with the word happy printed across) (Figure 10) or the facial emotion can be incongruent with the emotion label (e.g. a happy face with the word "sad" written across it) (See Figure 11). These stimuli were shown for 250 milliseconds following a beep. This task took approximately 10 minutes to complete.

2.3.e. McGurk Task

The stimuli were created using video recordings made in a sound attenuated room at the McMaster Institute for Music and the Mind (MIMM). Our "actor" was asked to recite triplets of the syllables "BA – BA", "GA – GA" and "DA – DA", with particular emphasis placed on clearly annunciating the sounds and producing clear lip movements. The video recordings were then edited to separate the audio tracks separated allowing the substitution of the audio recording for the BA-BA trial with audio of the GA-GA, creating an incongruent GAxBA condition where the audio voice stimulus was "GA-GA" and the video lip movement showed "BA-BA" . Before starting the task there were instructions slides outlining the objectives and rules. In this study there are twenty-four trials of four conditions (Congruent BA, GA, DA each consisting of 6 trials, and Incongruent GA x BA being shown 8 times), taking approximately 5 minutes to complete.

2.4 Procedure

All participants were invited to be tested in the exam rooms in McMaster's Psychology Building. In-home visits were offered if the parent or guardian believed the child would feel most comfortable there. Before the administration of the CASSA, participants (and parents) were given an in-depth explanation of the study background, current research questions, the participants' role in the research process and the consent forms (Appendix A-B). The parent or person most knowledgeable was asked to fill out a brief questionnaire regarding their child's history of ASD including past treatment history, and the dates of the interventions the family had tried. Questionnaires were administered to the parent either during the study in a separate room during the visit or immediately following the visit (Appendix D). Next, the laptop containing the CASSA was positioned in front of the participant. Between each task the child was asked if they were ready for the next task to start and were reminded that they could ask for a break at any time. The examiner explained each upcoming task to the child using the introductory slides in each of the assessment programs. The stimulus sequence of each task was generated randomly by the Psychopy program. After the five tasks were completed the parent and child were thanked and received a small remuneration.

2.5 Analysis

A comparison of means was performed using a Kruskal-Wallis test, using the response times and error rates of each group as variables. Before any comparison could be done a Shapiro-Wilk test was used to understand the nature of the data (whether either variable in any condition were normally distributed). The data would be considered normally distributed if the null hypothesis assumed by the Shapiro-Wilk is not met with a p-value larger than 0.05. The Kruskal-Wallis rank sum test is an appropriate method of comparing between group differences for non-parametric data specifically, with multiple variables with different sample sizes. This was ideal for the inconsistent completion rates of both groups within tasks. Cohen's d was calculated for the Independent Samples t test and effect size of the Kruskal-Wallis test by ranks was calculated using the H statistic created while performing a Kruskal-Wallis test. The data from each task was analysed using R Version 3.6.4 with packages tidyverse and rstatix.

2.5.a. Outliers of the McGurk Task and Theory of Mind

The Theory of Mind task and McGurk task both had no outliers identified as they rely on error rates not reaction time.

2.5.b. Identifying Navon Task Outliers

Outliers for reaction time were determined through a standard deviation analysis as advised by Aguinis, Gottfredson, & Joo (2013) we eliminate trials that exceed plus/minus 2.4 times the standard deviation from the mean calculated for each group per variable. For the selected attention, we asked participants to look for a specific target at a predetermined level either global or local. The selective attention local incongruent stimuli occur when the target is present at the local level but the global image is different.

2.5.c. Identifying Blur Task Outliers

There were two button presses in sequence for which response times were recorded; the response when the participant felt they knew what the emotion was and the response when a selection was made regarding the emotion displayed. Using the standard deviation analysis as advised by Aguinis, Gottfredson, & Joo (2013) we eliminate trials that exceed plus/minus 2.4 times the standard deviation from the mean calculated from each group per variable. Since this task relies on videos that unblur and no feature becomes distinguishable until three seconds, the we decided that any response time faster than three seconds would also be labeled as an error.

2.5.d. Identifying Emotional Stroop Outliers

During the processing of the vocal data to yield a reaction time for each participant the audio recording provided the means to determine clear error outliers where a participant or administrator interrupted to the program. The averages of both reaction time and error are presented table below include reaction time and error regardless of condition, followed by the congruent stimuli (the face matched the emotion word) or incongruent. Finally, an average reaction time and error was identified for positive and negative emotions for each participant.

RESULTS

3.1 Theory of Mind Task

The Theory of Mind Task (ToM Task) between groups performance was compared using a Kruskal-Wallis which compares between group differences based on scores for nonparametric data. This was determined appropriate after the data was significantly not normal with a Shapiro-Wilk test score for the first stimuli block testing First Order ToM $W(21) = 0.658$, $p = 0.000004$ and Second Order ToM $W(21) = 0.8$, $p = 0.0003$. The effect size was calculated through the H statistic from the Kruskal Wallace test using eta squared. The first block focused on perspective taking, and on these tasks both controls and children with autism performed at ceiling (did not make a single mistake) and therefore no group comparison was possible. The error bars represent the standard deviation used to analyze outlier responses.

Figure 2. A between group analysis was conducted to compare the accuracy score between controls (n=11) and the ASD (n=12) groups within two conditions (First and Second Order ToM). There was no significant difference found between the error rates of control (mean = 0.454, sd = 0.15) and autism (mean = 0.375, sd = 0.31) groups in the First Order condition using a Kruskal-Wallis test (H(1)= 0.781, p= 0.377) with a small effect size (η^2 = -0.0104). There was no significant correlation between group and error on the First Order ToM stimuli using a Spearman correlation for First Order (rs (21) = -0.188, p = 0.389). A Kruskal-Wallis test indicated that there was no significant difference between error rates of the control (mean = 0.363, sd = 0.323) and ASD group (mean = 0.458, sd = 0.45) during the Second Order condition; (H(1)= 0.213, p=0.644) with a small effect size (η^2 = -0.0375). The results of a Spearman correlation indicate no significant correlation to group designation and error rate in the Second Order condition (rs (21) = 0.098, p = 0.655).

3.2 Navon Task

Selective attention was analysed at the local and global levels using response time and error rate to investigate between group differences. A Global incongruent stimulus would have the target number as the local or "small" number while the global or "large" image would be that of a number different from the target. A locally incongruent stimulus is one in which the target is located Globally while the local image is different. All comparisons of means using response time and error on congruent and incongruent trials were done with a Kruskal-Wallis test and a Spearman correlation test. This was due to a significant result on all Shapiro-Wilk assessment of normal distribution displayed in Table 4. The error bars represent the standard deviation used to analyze outlier responses.

Condition	W	DF	P-value
Selective Attention Local			
RT for Congruent Stimuli	0.71034	21	1.91E-05
RT for Incongruent Stimuli	0.82961	21	0.001187
Error of Congruent Stimuli	0.52105	21	1.37E-07
Error of Incongruent Stimuli	0.53022	21	1.69E-07
Selective Attention Global			
RT for Congruent Stimuli	0.69191	21	1.10E-05
RT for Incongruent Stimuli	0.72629	21	3.13E-05
Error of Congruent Stimuli	0.53802	21	2.02E-07
Error of Incongruent Stimuli	0.68183	21	8.21E-06
Divided Attention			
RT for Locally Incongruent	0.83813	21	0.00167
RT for Globally Incongruent	0.84575	21	0.00228
Error of Locally Incongruent	0.87701	21	0.008751
Error of Globally Incongruent	0.81842	21	0.0007668

Table 3. Results of the Shapiro-Wilk for each condition before the handling of outlier data

Condition	W	DF	P-value
Selective Attention Local			
RT for Congruent Stimuli	0.77599	21	0.000162
RT for Incongruent Stimuli	0.83241	21	0.001327
Error of Congruent Stimuli	0.5228	21	1.43E-07
Error of Incongruent Stimuli	0.52388	21	1.46E-07
Selective Attention Global			
RT for Congruent Stimuli	0.7172	21	2.36E-05
RT for Incongruent Stimuli	0.81379	21	0.0006423
Error of Congruent Stimuli	0.47716	21	5.22E-08
Error of Incongruent Stimuli	0.68183	21	8.21E-06
Divided Attention			
RT for Locally Incongruent	0.87157	21	0.006871
RT for Globally Incongruent	0.90492	21	0.03197
Error of Locally Incongruent	0.87774	21	0.009042
Error of Globally Incongruent	0.81266	21	0.0006153

Table 4. Results of the Shapiro-Wilk for each condition after the handling of outlier data

3.2. After the Handling of Outlier Data

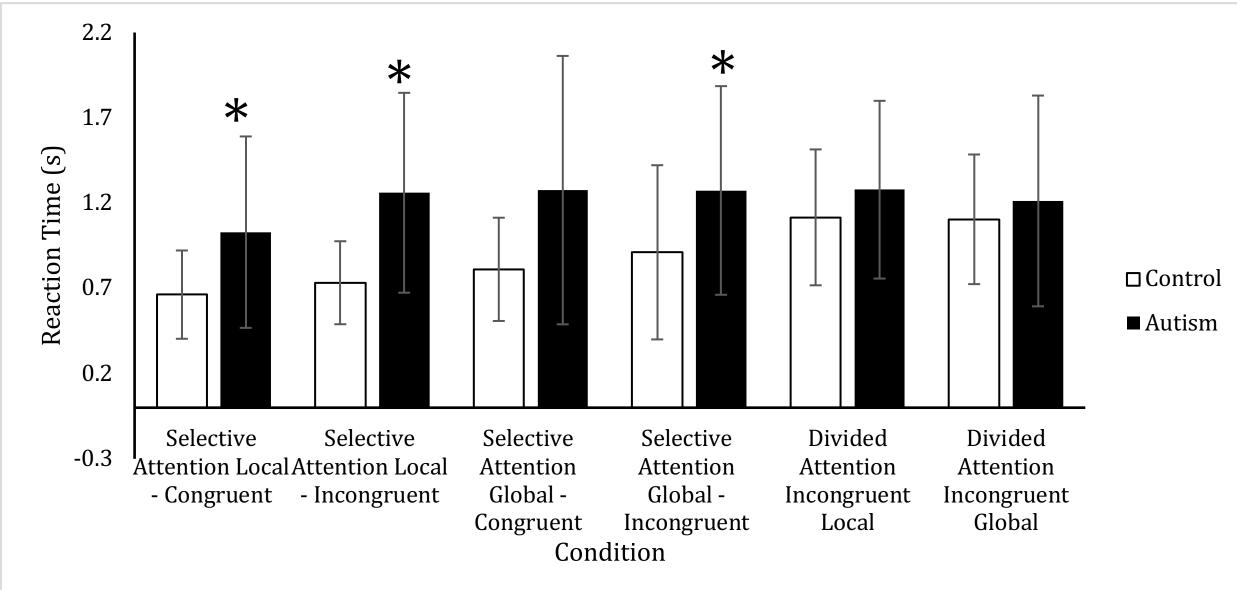

Figure 3. Comparison of reaction time between control (n=11) and Autism (n=13) groups when asked to identify a target at different levels of attention.

Selective Attention Local - Congruent Using a Kruskal-Wallis test a significant difference was found between the reaction time of the control (mean = 0.662, sd = 0.258) and autism group (mean = 1.029, sd = 0.561) during the selective attention with a congruent stimuli condition; ($H(1) = 4.98$, $p = 0.025$) with a large effect size ($\eta^2 = 0.19$). A Spearman correlation found a significant positive correlation between group and reaction time during selective attention local with congruent stimuli condition (rs (21) = 0.475, $p = 0.021$).

Selective Attention Local - Incongruent A Kruskal-Wallis test found a significant difference between the reaction time of control (mean = 0.732, sd = 0.243) and autism group (mean = 1.26, sd = 0.585) during the selective attention local target with an incongruent stimuli condition; ($H(1) = 8.14$, $p = 0.004$) with a large effect size ($\eta^2 = 0.34$). A Spearman correlation found a significant positive correlation between group and reaction time during the selective attention local incongruent condition (rs (21) = 0.608, p = .002).

Selective Attention Global – Congruent There was no significant difference indicated by a Kruskal-Wallis test between the reaction time of the control (mean = 0.811, sd = 0.302) and autism group (mean = 1.275, sd = 0.786) during the selective attention global target with a congruent stimuli condition; (H(1) = 2.4, p = 0.121) with a moderate effect size (η^2 = 0.066). A Spearman correlation found no significant correlation between group and condition (rs (21) = 0.33, p = 0.123).

Selective Attention Global - Incongruent A Kruskal-Wallis test found a significant difference between the reaction time of the control (mean = 0.911, sd = 0.51) and autism group (mean = 1.273, sd = 0.611) during the selective attention global target with an incongruent stimuli condition; (H(1) = 4.98, p = 0.025) with a large effect size (η^2 = 0.19). A Spearman correlation found a significant positive correlation between group and reaction time during this condition (rs (21) = 0.475, p = 0.021).

Divided Attention Incongruent Local A Kruskal-Wallis test showed no significant difference found between the reaction time of the control (mean = 1.116, sd = 0.398) and autism group (mean = 1.278, sd = 0.521) during the divided attention with a local incongruent stimuli condition; (H(1) = 0.307, p = 0.58) with a small effect size (η^2 = -0.033). A Spearman correlation found no significant correlation between group and condition (rs (21) = 0.118, p = 0.591).

Divided Attention Incongruent Global A Kruskal-Wallis test found no significant difference between the reaction time of the control (mean = 1.104, sd = 0.38) and autism group (mean = 1.212, sd = 0.618) during the divided attention with a global incongruent stimuli condition; (H(1)

= 0.85, $p = 0.254$) with a small effect size ($\eta^2 = -0.047$). A Spearman correlation found no significant correlation between group and condition ($r_s(21) = -0.178$, $p = 0.916$).

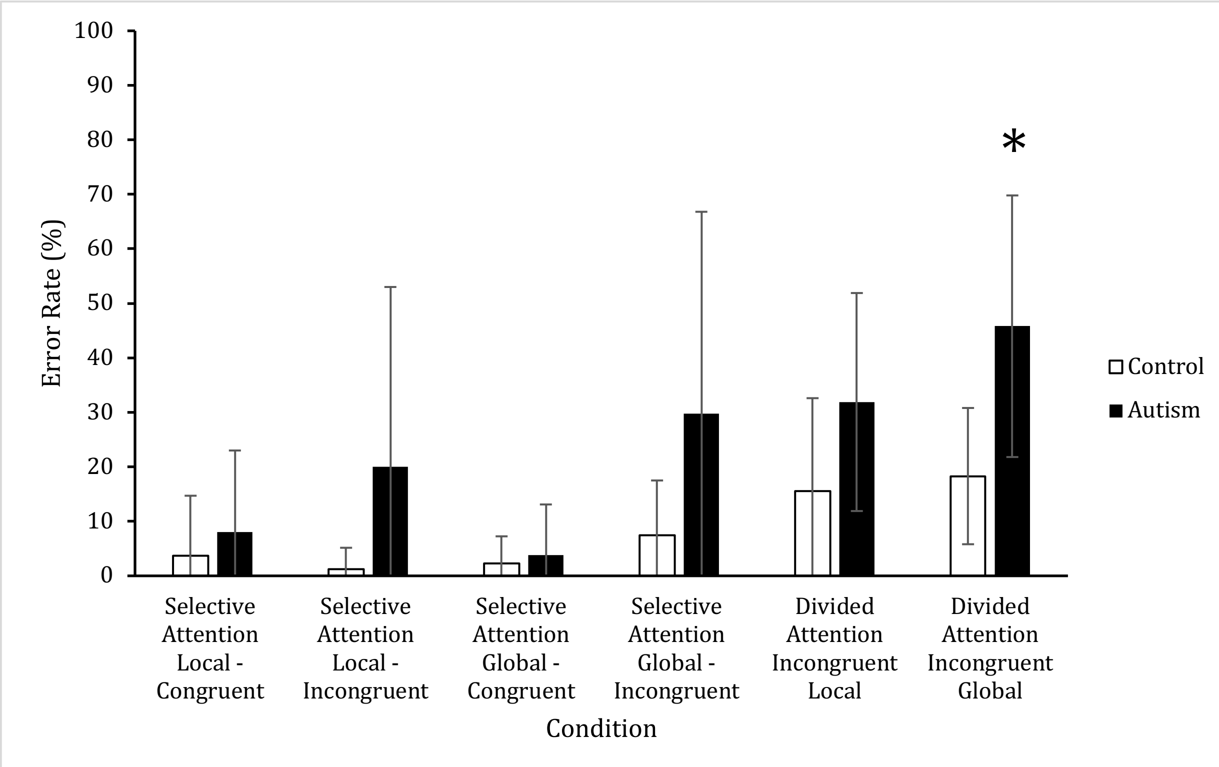

Figure 4. Comparison of error rates between control (n=11) and Autism (n=13) groups when asked to identify a target at different levels of attention.

Selective Attention Local - Congruent A Kruskal-Wallis test found no significant difference between the error rates of the control (mean = 0.037, sd = 0.118) and autism group (mean = 0.08, sd = 0.153) during the selective attention local target with a congruent stimuli condition; (H(1) = 1.15, p = 0.283) with a small effect size (η^2 = 0.007). A Spearman correlation found no significant correlation between group and condition (rs (21) = 0.229, p = 0.293).

Selective Attention Local - Incongruent A Kruskal-Wallis test indicated no significant difference between the error rates of the control (mean = 0.012, sd = 0.039) and autism group (mean = 0.208, sd = 0.334) during the selective attention local target with an incongruent stimuli condition; (H(1) = 2.71, p = 0.099) with a moderate effect size (η^2 = 0.081). A Spearman correlation found no significant correlation between group and condition (rs (21) = 0.351, p = 0.101).

Selective Attention Global – Congruent There was no significant difference found between the error rates of the control (mean = 0.025, sd = 0.052) and autism group (mean = 0.038, sd = 0.093) during the selective attention global target with a congruent stimuli using a Kruskal-Wallis test; (H(1) = 0.008, p = 0.925) with a small effect size (η^2 = -0.047). A Spearman correlation found no significant correlation between group and performance during this condition (rs (21) = -0.02, p = 0.927).

Selective Attention Global - Incongruent A Kruskal-Wallis test found no significant difference between the error rates of the control (mean = 0.075, sd = 0.105) and autism group (mean = 0.298, sd = 0.376) during the selective attention global target with an incongruent stimuli condition; (H(1) = 2.11, p = 0.146) with a small effect size (η^2 = 0.053). A Spearman correlation found no significant correlation between group and performance during this condition (rs (21) = 0.309, p = 0.15).

Divided Attention Incongruent Local A Kruskal-Wallis test showed no significant difference found between the error rates of the control (mean = 0.156, sd = 0.173) and autism group (mean = 0.318, sd = 0.203) during the divided attention with a local incongruent stimuli condition; (H(1) = 3.15, p = 0.075) with a moderate effect size (η^2 = 0.102). A Spearman correlation found no significant correlation between group and performance during this condition (rs (21) = 0.378, p = 0.075).

Divided Attention Incongruent Global There was a significant difference found using a Kruskal-Wallis test between the error rates of the control (mean = 0.083, sd = 0.125) and autism group (mean = 0.458, sd = 0.24) during the divided attention with a global incongruent stimuli condition; ($H(1) = 8.11$, $p = 0.004$) with a large effect size ($\eta^2 = 0.339$). A Spearman correlation found a significant positive correlation between group and error rate during a divided attention incongruent global condition (r_s (21) = 0.607, $p = 0.002$).

3.3 Blur into Focus Task

The Blur into Focus task has three conditions of unblurring different parts of the face (Whole face, mouth first, eyes first) as well as four emotion conditions (happy, angry, fearful, sad). A Shapiro-Wilk test was first used to assess whether the data was parametric or non-parametric within each blurring and emotion condition. As a result of the non-normally distributed data a Kruskal-Wallis test was used to compare the error rate and response time of controls and children with autism within each blurring and emotion conditions.

To investigate the group differences in responding to positive and negative emotions, happy faces response times were averaged regardless of blur condition. The averaged response times of the three negative emotions were compiled together (fearful, angry, sad) and analysed between groups as well as separated into their respective conditions. This was done to assess the impact of positive and negative emotions played in the overall accuracy and response time by group before investigating each individual emotion condition. The error bars represent the standard deviation used to analyze outlier responses.

Condition	W	DF	P-value
Reaction Time for Positive Stimuli	0.73062	18	9.44E-05
Reaction Time for Negative Stimuli	0.7354	18	1.09E-04
Reaction Time Angry	0.67081	18	1.75E-05
Reaction Time Fearful	0.80039	18	0.0008755
Reaction Time Sad	0.78358	18	4.97E-04
Error of Positive Stimuli	0.67536	18	1.98E-05
Error of Negative Stimuli	0.84846	18	0.005023
Error of Angry	0.86132	18	0.008298
Error of Fearful	0.91404	18	0.07613
Error of Sad	0.85963	18	0.007762
Reaction Time Whole Face	0.75854	18	2.22E-04
Reaction Time Mouth	0.66262	18	1.41E-05
Reaction Time Eyes	0.76484	18	2.70E-04
Error of Whole Face	0.96583	18	0.6655
Error of Mouth	0.89205	18	0.02933
Error of Eyes	0.86999	18	0.01174

Table 5. Results of the Shapiro-Wilk for each condition before the handling of outlier data

Condition	W	DF	P-value
Reaction Time for Positive Stimuli	0.84795	18	0.004927
Reaction Time for Negative Stimuli	0.80782	18	0.001133
Reaction Time Angry	0.85383	18	0.006183
Reaction Time Fearful	0.80616	18	0.001069
Reaction Time Sad	0.76793	18	0.0002983
Error of Positive Stimuli	0.64853	18	9.79E-06
Error of Negative Stimuli	0.87197	18	0.01273
Error of Angry	0.88167	18	0.01896
Error of Fearful	0.96968	18	0.7482
Error of Sad	0.77345	18	3.56E-04
Reaction Time Whole Face	0.8165	18	0.001539
Reaction Time Mouth	0.86789	18	0.01079
Reaction Time Eyes	0.8248	18	0.002074
Error of Whole Face	0.93689	18	0.2093
Error of Mouth	0.89176	18	0.02897
Error of Eyes	0.87197	18	0.01273

Table 6. Results of the Shapiro-Wilk for each condition after the handling of outlier data

3.3 After the Handling of Outlier Data

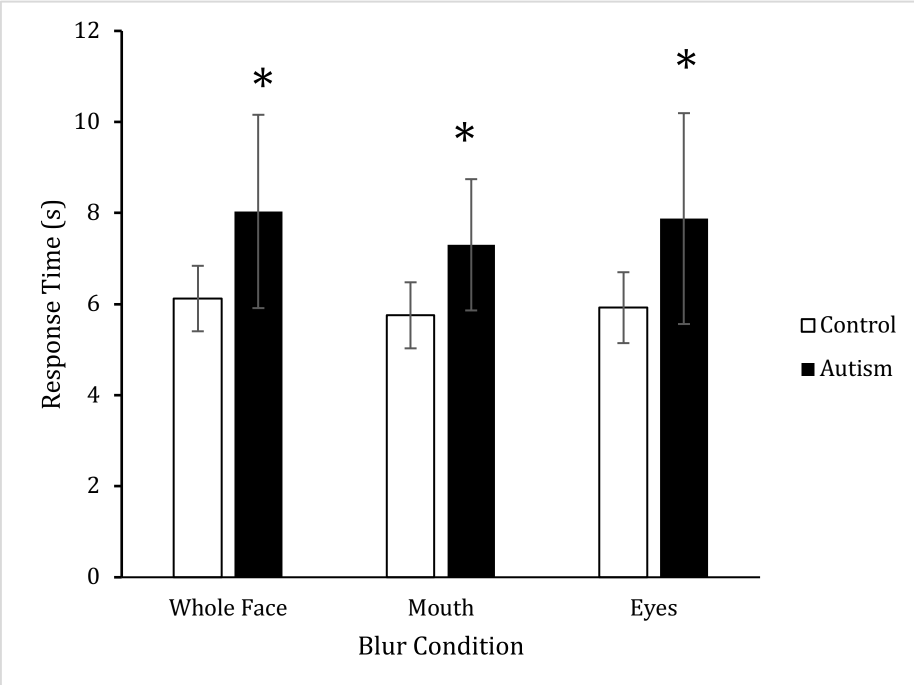

Figure 5. Comparison of response time between control (n=11) and Autism (n=9) groups when asked to identify the emotion of an unblurring face. There are three separate ways in which the faces come into focus whole face, mouth first or eyes first.

Whole Face A Kruskal-Wallis test found that when the whole face unblurred, controls (mean = 6.121, sd = 0.719) were significantly faster than the autism group (mean = 8.035, sd = 2.122) ($H(1) = 4.05$, $p = 0.044$) with a large effect size ($\eta^2 = 0.17$). A Spearman correlation found a positive correlation between controls and autism using response time during the whole face unblurring condition ($r_s (18) = 0.461$, $p = 0.04$).

Mouth A Kruskal-Wallis test found significant difference between the response times of controls (mean = 5.753, sd = 0.725) compared to the children with autism (mean = 7.302, sd = 1.441) during the mouth unblurring first condition ($H(1) = 6.48$, $p = 0.01$) with a large effect size ($\eta^2 = 0.304$). A Spearman correlation found a significant positive correlation between group and response time during the mouth first unblurring condition ($r_s (18) = 0.583$, $p < 0.001$).

Eyes A Kruskal-Wallis test found a significant difference found between the response time of the control (mean = 5.921, sd = 0.778) and autism group (mean = 7.877, sd = 2.315) during the eyes unblurring condition; ($H(1) = 4.37$, $p = 0.036$) with a large effect size ($\eta^2 = 0.187$). A Spearman correlation found a significant positive correlation between group and the eyes unblurring first condition ($r_s (18) = 0.479$, $p = 0.032$).

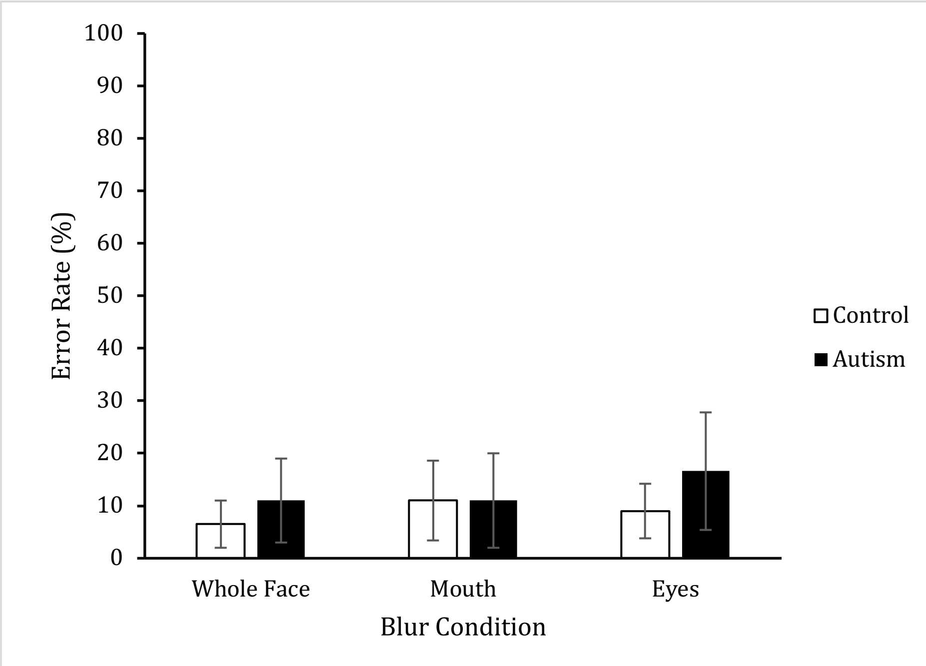

Figure 6. Comparison of accuracy between control (n=11) and Autism (n=9) groups when asked to identify the emotion on an unblurring face. There are three separate conditions in which the faces come into focus whole face, mouth first or eyes first.

Whole Face A Kruskal-Wallis test found no significant difference in error rates between controls (mean = 0.066, sd = 0.045) and the autism group (mean = 0.117, sd = 0.085) during the whole face unblurring condition (H(1) = 2.69, p = 0.101) with a moderate effect size (η^2 = 0.093). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18) = 0.376, p = 0.102).

Mouth A Kruskal-Wallis test found no significant difference between the error rates of controls (mean = 0.106, sd = 0.076) compared to children with ASD (mean = 0.114, sd = 0.096) during the mouth unblurring first condition (H(1) = 0.013, p = 0.909) with a small effect size (η^2 = -0.054). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18) = 0.026, p = 0.912).

Eyes A Kruskal-Wallis test found no significant difference between the error rates of the control (mean = 0.097, sd = 0.052) and autism group (mean = 0.166, sd = 0.112) during the eyes unblurring condition; ($H(1) = 3.62$, $p = 0.057$) with a large effect size ($\eta^2 = 0.146$). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18(= 0.436, p = 0.054).

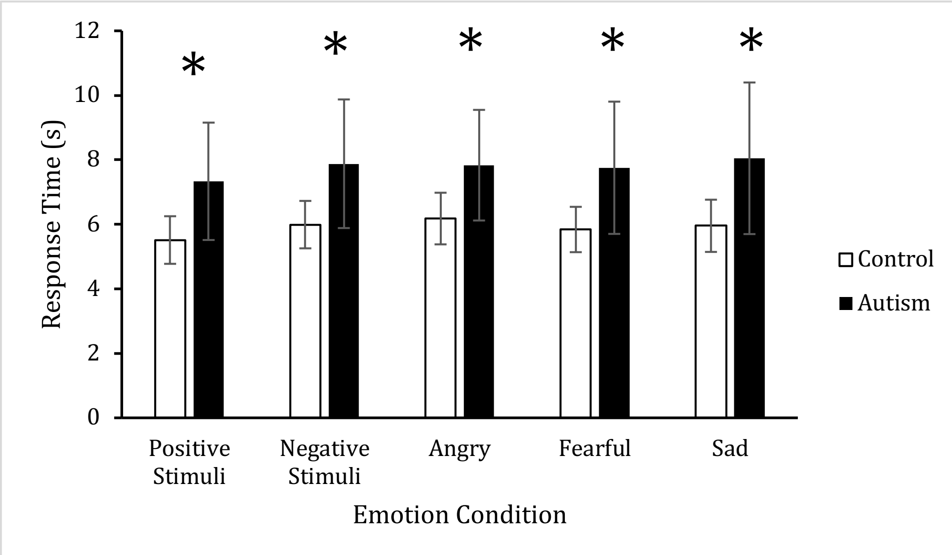

Figure 7. Comparison of response time between control (n=11) and Autism (n=9) groups when asked to identify the facial emotion

Positive Stimuli A Kruskal-Wallis test found a significant difference between controls (mean = 5.513, sd = 0.737) and autism (mean = 7.334, sd = 1.819) groups when comparing their response time during positive stimuli conditions (H(1) = 5.02, p = 0.025) with a large effect size (η^2 = 0.224). A Spearman correlation found a significant positive correlation between group and response time during the positive stimuli condition (rs (18) = 0.514, p = 0.02).

Negative Stimuli A Kruskal-Wallis test found a significant difference between the response times of controls (mean = 5.991, sd = 0.735) and autism (mean = 7.878, sd = 1.994) groups during the negative stimuli condition (H(1) = 6.1, p = 0.013), with a large effect size (η^2 = 0.283). A Spearman correlation found a positive correlation between group and response time during the negative stimuli condition (rs (18) = 0.566, p = 0.009).

Angry A Kruskal-Wallis test found a significant difference between the response times of controls (mean = 6.179, sd = 0.8) and autism (mean = 7.833, sd = 1.715) groups comparing response time during the angry condition (H(1) = 5.02, p = 0.025), with a large effect size (η^2 =

0.224). A Spearman correlation found a positive correlation between group and response time during the angry condition (rs (18) = 0.514 p = 0.02).

Fearful A Kruskal-Wallis test found a significant difference between the response times of controls (mean = 5.839, sd = 0.702) and autism (mean = 7.754, sd = 2.05) groups during the fearful condition (H(1) = 4.05, p = 0.044), with a large effect size ($\eta^2 = 0.17$). A Spearman correlation found a significant positive correlation between group and response time during the fearful condition (rs (18) = 0.461, p = 0.04).

Sad A Kruskal-Wallis test found a significant difference between the response times of controls (mean = 5.954, sd = 0.809) and autism (mean = 8.048, sd = 2.35) groups during the sad condition (H(1) = 6.1, p = 0.013), with a large effect size ($\eta^2 = 0.283$). A Spearman correlation found a significant positive correlation between group and response time during this condition, (rs (18) = 0.566, p = 0.009).

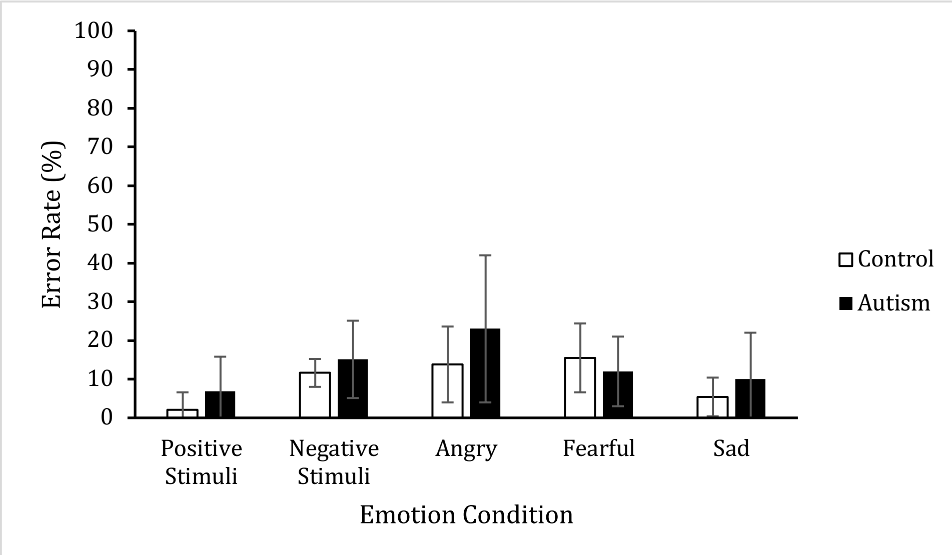

Figure 8. Comparison of error rate between control (n=11) and Autism (n=9) groups when asked to identify the facial emotion.

Positive Stimuli A Kruskal-Wallis test found no significant difference between the error rates of controls (mean = 0.02, sd = 0.046) and autism (mean = 0.068, sd = 0.095) groups during the positive stimuli condition (H(1) = 2.25, p = 0.133) with a moderate effect size ($\eta^2 = 0.069$). A Spearman correlation found no significant correlation between group and error rate during the positive stimuli condition (rs (18) = 0.344, p = 0.137).

Negative Stimuli A Kruskal-Wallis test found no significant difference between the error rates of controls (mean = 0.116, sd = 0.036) and autism (mean = 0.151, sd = 0.107) groups during the negative stimuli condition (H(1) = 0.417, p = 0.518), with a small effect size ($\eta^2 = -0.032$). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18) = 0.148, p = 0.533).

Angry A Kruskal-Wallis test found no significant difference between the error rates of controls (mean = 0.138, sd = 0.098) and autism (mean = 0.23, sd = 0.194) groups during the angry condition (H(1) = 1.06, p = 0.304), with a small effect size ($\eta^2 = 0.003$). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18) = 0.235, p = 0.316).

Fearful A Kruskal-Wallis test found no significant difference between the error rates of controls (mean = 0.155, sd = 0.089) and autism (mean = 0.121, sd = 0.093) groups during the fearful condition (H(1) = 0.326, p = 0.568), with a small effect size (η^2 = -0.047). A Spearman correlation test found no significant correlation between group and performance during this condition, (rs (18) = -0.13, p = 0.582). **Sad** A Kruskal-Wallis test found no significant difference between the error rates of controls (mean = 0.054, sd = 0.053) and autism (mean = 0.103, sd = 0.12) groups during the sad condition (H(1) = 0.921, p = 0.337), with a small effect size (η^2 = -0.004). A Spearman correlation test found no significant correlation between group and performance during this condition, (rs(18) = 0.22, p = 0.351).

3.4 Emotional Stroop Task

The response time and error rate of participants for the 80 stimuli of mixed trials of congruent and incongruent stimuli were compared between groups using a Kruskal-Wallis as a result of a significant score on the Shapiro-Wilk test for each condition (Table 11-12). Each condition was tested to confirm the nonparametric nature before a Kruskal-Wallis test was done. The baseline measures of reading speed and facial emotion recognition (The first two baseline blocks of twenty trials each) were not included as participants scored at the ceiling. The error bars represent the standard deviation used to analyze outlier responses.

Condition	W	DF	P-value
Reaction time regardless of condition	0.81867	15	0.0037
Reaction time of Congruent Stimuli	0.84797	15	0.009989
Reaction time of Incongruent Stimuli	0.81594	15	0.003383
Error regardless of condition	0.83675	15	0.006779
Error of Congruent Stimuli	0.70597	15	0.0001352
*Error of Incongruent Stimuli	0.9374	15	0.2886
Reaction Time for Positive Stimuli	0.77162	15	0.0008497
Reaction Time for Negative Stimuli	0.82927	15	0.005261
Error of Positive Stimuli	0.81432	15	0.00321
*Error of Negative Stimuli	0.91134	15	0.1054

Table 7. Results of the Shapiro-Wilk for each condition. The error rate of incongruent stimuli and negative stimuli were not found significant using the Shapiro-Wilk test which made using an independent samples t-test appropriate for these two factors (Shown below).

Condition	T Stat	DF	P-value	Control Mean	Autism Mean	Effect Size	ES Descr
Error of Incongruent Stimuli	-1.9868	15	0.06553	0.2492336	0.4095721	-1.01	Large
Error of Negative Stimuli	-3.042	15	0.008237	0.1895599	0.4189941	-1.54	Large

Table 8. The results of the t-test performed for the two conditions that were normally distributed as indicated by a Shapiro-Wilk test.

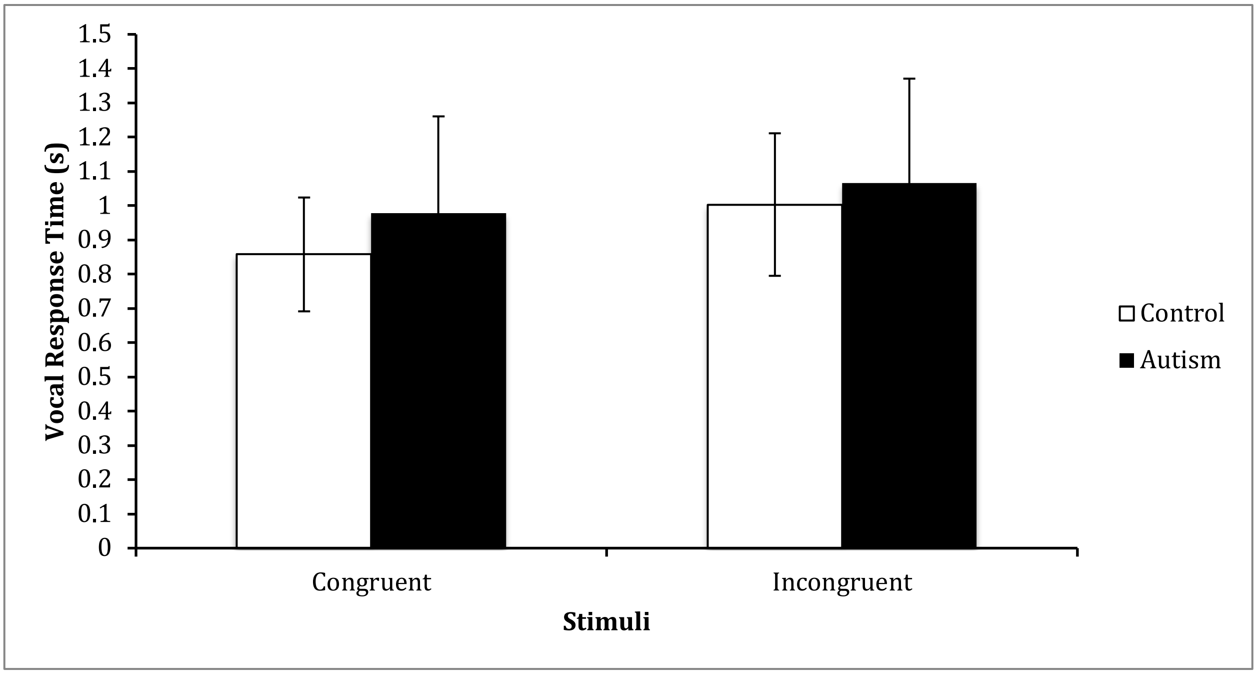

Figure 9. Comparison of vocal response time between control (n=12) and Autism (n=6) groups when asked to identify the emotion displayed by a face with an emotion word which was either congruent (matching the displayed emotion) or incongruent.

Congruent There was no significant difference found between controls (mean =.857, sd = 0.166) and autism (mean =.978, sd = 0.282) using response time when the stimuli was congruent using a Kruskal-Wallis test;(H(1)= 0.646, p= 0.421) with a small effect size (η^2 = -0.023). The Spearman correlation was not significant between the control group and autism group using response time for congruent stimuli (rs (15) =0.201, p = 0.439).

Incongruent A Kruskal-Wallis test found no significant difference of response time between control (mean =1.003, sd = 0.208) and autism (mean =1.066, sd = 0.303) when identifying the incongruent stimuli;(H(1)= 0.0404, p=0.841) with a small effect size (η^2 = -0.064). The Spearman correlation test found no significant correlation between the control group and autism group using response time for incongruent stimuli (rs (15)= 0.848, p = 0.05).

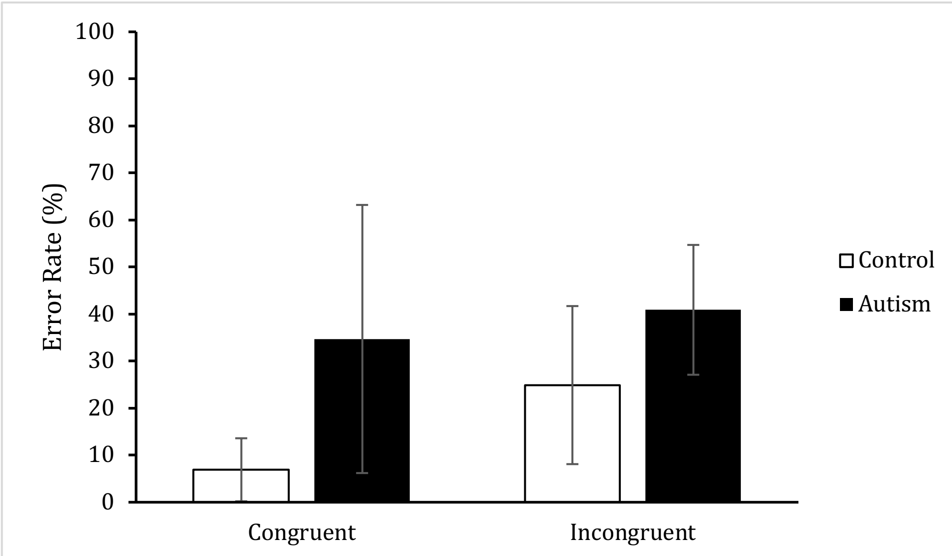

Figure 10. Comparison of error rate between control (n=12) and Autism (n=6) groups when asked to identify the emotion displayed by a face with an emotion word which was either congruent (matching the displayed emotion) or incongruent.

Congruent A Kruskal-Wallis test found a significant difference between the error rate of the control (mean= 0.069, sd = 0.067) and autism group (mean = 0.347, sd = 0.283) during the congruent stimuli (H(1)= 5.18, p= 0.022) with a large effect size (η^2 = 0.279). The Spearman rank correlation indicates a significant positive correlation between group and error rate when identifying the emotion for congruent stimuli, (rs(15)= 0.569, p = 0.017).

Incongruent A Kruskal-Wallis test found no significant difference during the incongruent emotion condition between the control (mean = 0.249, sd = 0.168) and ASD group (mean = 0.409, sd = 0.138) (H(1)= 3.28, p=0.07) but did have a large effect size (η^2 = 0.152). The Spearman correlation found no significant correlation between the control and autism groups using error rate for incongruent stimuli (rs (15) = 0.452, p = 0.068).

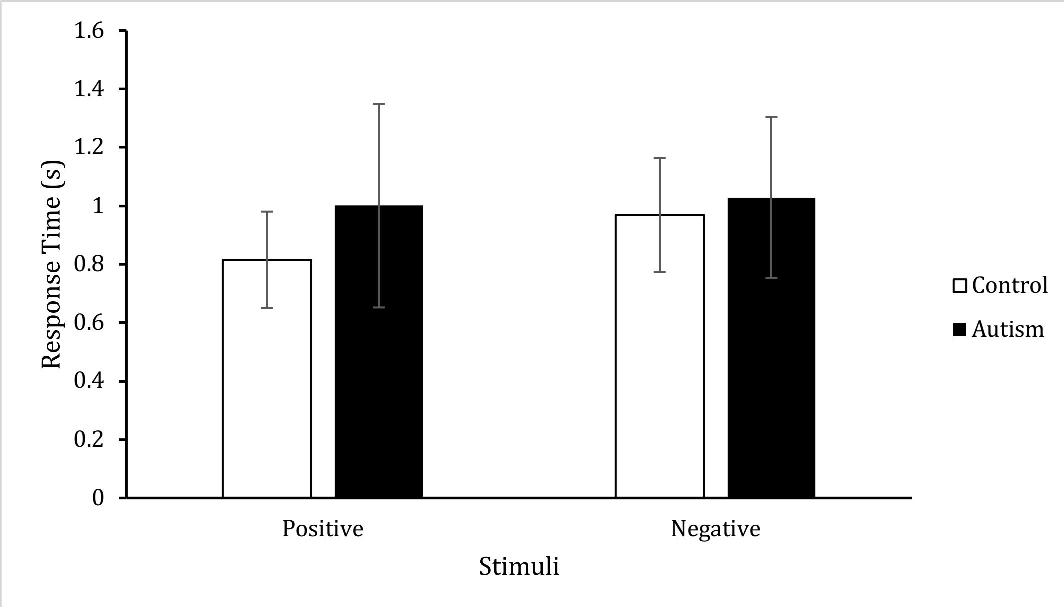

Figure 11. Comparison of response time between control (n=12) and Autism (n=6) groups when asked to identify the positive or negative emotion displayed by a face with an emotion word overlaid.

Positive The Kruskal-Wallis test did not find a significant difference between control (mean= 0.815, sd = 0.164) and autism (mean = 1.001, sd = 0.348) during the positive stimuli condition (H(1)= 0.646, p= 0.421) with a small effect size (η^2= -0.023). Results from the Spearman correlation indicate there was no relationship between group and response time during positive trials, (rs (15) = .201, p = .439).

Negative A Kruskal-Wallis test comparing the response times during negative emotion recognition did not find significant differences between the control (mean = 0.968, sd = 0.195) and ASD group (mean = 1.02, sd = 0.276) (H(1)= 0.162, p = 0.688) with a small effect size (η^2= -0.055). A Spearman correlation found no significant difference between group and response time, (rs (15) = 0.101, p = 0.701).

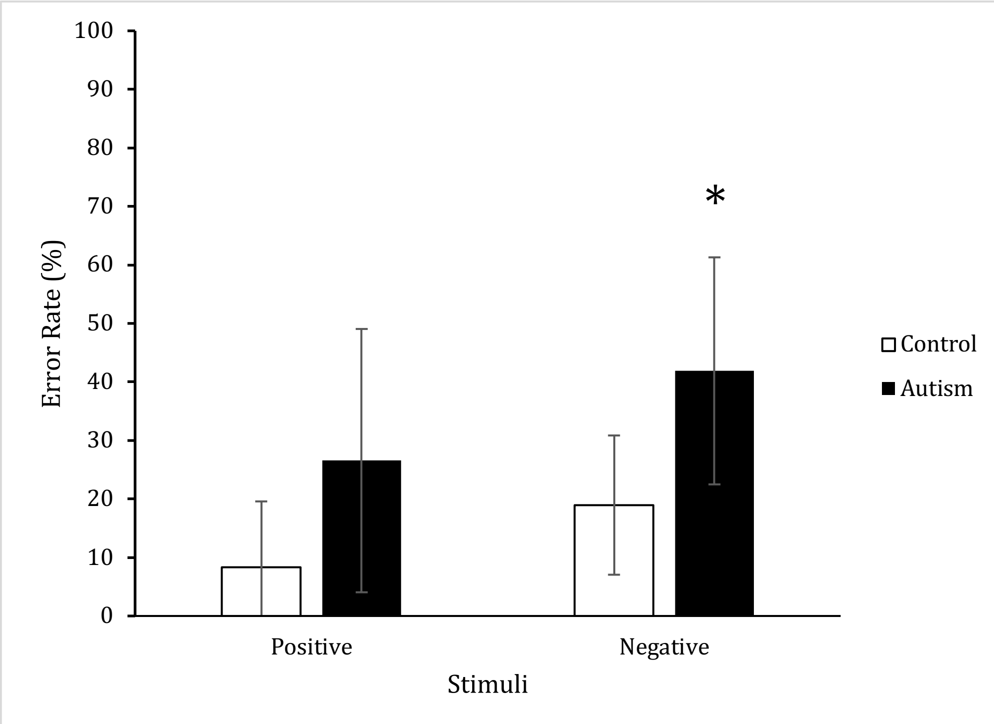

Figure 12. Comparison of error rates between control (n=12) and Autism (n=6) groups when asked to identify the emotion of a face with an overlay of an emotion word.

Positive A Kruskal-Wallis test did not find a significant difference between error rates of control (mean= 0. 082, sd = 0.113) and autism groups (mean = 0.275, sd = 0. 225) during the positive stimuli condition (H(1)= 3.25, p= 0.071) but did have a large effect size (η^2 = 0.15). A Spearman correlation indicates that there was no correlation between group and error rates during the positive condition, (rs(15) = 0.45, p = 0.069).

Negative A Independent Samples t-test found a significant difference using error rate during the negative emotion condition between controls (mean = 0.189, sd = 0. 119) and the ASD group (mean = 0. 418, sd = 0. 194) (t(15) = -3042, p = 0.008). Kruskal-Wallis test showed that the negative emotion condition did have a significant difference between the error rates of the control (mean = 0.189, sd = 0. 119) and ASD group (mean = 0. 418, sd = 0. 194) (H(1)= 4.45, p = 0.034) and a large effect size (η^2 = 0.23). A Spearman correlation test indicated that there is a positive correlation between group error rates during the negative emotion condition, (r_s (15) = 0. 527, p = 0.029).

3.5 McGurk Task

Between group analysis of the McGurk task examined error percentage on the incongruent stimulus (errors are defined by the selection of the combined percept heard with a successful McGurk Effect; in this study Visual Ga x Audio Ba the combined percept would be Da). These differences were the focus as both groups did not make an error on the congruent stimuli. The variable of error was assessed to exceed the bounds of normal distribution through a significant result in a Shapiro-Wilk test ($W(18) = 0.64425$, $p = 0.000008$). A Kruskal-Wallis test was used to compare the means of the control and autism groups as a result of the non-parametric nature of the data. The error bars represent the standard deviation used to analyze outlier responses.

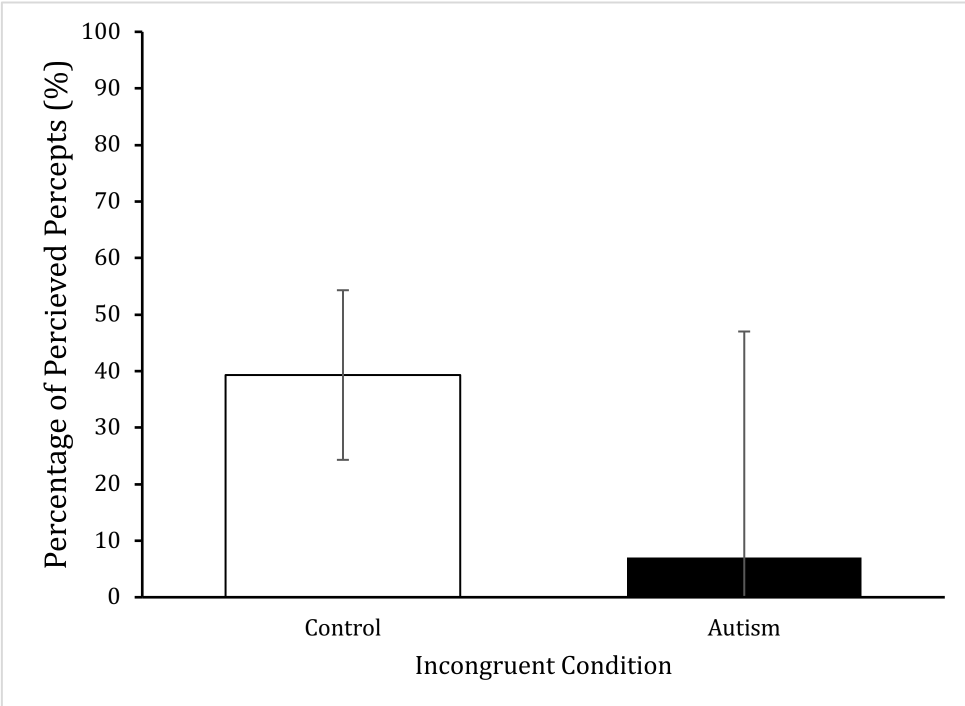

Figure 13. Error rates between control (n=8) and autism (n=12) groups when asked to identify the sound heard when a video displaying an incongruent visual and audio was displayed. A Kruskal-Wallis test found no significant difference of error during the incongruent stimuli between the control (mean = 0.393, sd = 0.155) and the ASD (mean = 0.07, sd = 0.402) groups; (H(1)= 0.388, p= 0.533) with a small effect size (η^2 = -0.034). Results of the Spearman correlation indicate no association between group and error rate, (rs (18) = -0.142, p = 0.547).

DISCUSSION

4.1 Theory of Mind Task

Children with autism were more accurate than controls in the first order condition although from our observations during the task, this difference may be explained by the waning attention of the controls once they identified a game as "easy" or "simple". There was a reversal of error rates during the second order theory of mind condition although none of these changes were significant.

4.1.a. Future Improvements

Children with autism and neurotypical controls responded positively to the cartoons, maintaining their interest throughout. Although the cartoons were not on par with modern television in terms of complexity or quality, they were stimulating enough to hold the attention of both groups. In the TOM task, each question period after watching a video was given in a multiple-choice format, consisting of two choices. This may allow a participant to correctly guess an answer even if they did not understand what was being asked of them. Adding multiple answers, including distractor items greatly reduces the impact of guessing. The language used in the questions themselves may be simplified in the future so as to make the task more child friendly and to lower the requirement of highly developed language skills. This may be insightful to add further into the discussion surrounding language development and the acquisition of theory of mind abilities (Sera & Martin, 2006).

4.2 Navon Task

Our prediction for the autism group were based on the theory of preferential processing of local images and thus a stimulus with the target on a global level with an incongruent local image would be the most difficult item for children with autism. A significant difference found between our groups based on reaction time for the selective attention global incongruent condition (when the stimuli had a locally incongruent image while the target is on the global level) ($p = 0.025$). This pattern was also seen in the divided attention condition where a significant difference was found comparing the error rates when the target was found on the global level while there was incongruent numbers on the local level ($p = 0.004$) with a large effect size ($\eta^2 = 0.339$) and a positive Spearman correlation ($p = 0.002$). This is in line with preferential processing at local level for ASD and demonstrates the potential for a computer task to measure the construct of local/global processing, aiding in a more descriptive diagnostic battery.

The level of engagement from participants was of interest to the study and that is why the Navon Task seemed to be the most successful of any of the games. Multiple participants in both the control and autism groups asked to rerun this task as it was a fun game. There were more button presses per second than any other game and this may be why the participants (both those with autism and without) were able to pay attention more consistently for the duration of the task. The game continually required interaction to move forward, preventing the participants from distraction.

4.2.a. Future Improvements

The Navon task was well designed and showed significant performance-based differences between the neurotypical controls and the autism spectrum disorder group. One simple improvement would be the addition of practice rounds so that the reaction times recorded will always reflect the processing abilities of the participants and not their ability to learn new tasks.

4.3 Blur into Focus Task

The Blur task measures facial emotional processing and whether this ability is affected by the area of the face that information comes from. The task gathers response time at the beginning of the video until the initial button press when the participant acknowledges they have identified the emotion, and a secondary response time of emotion selection. The participants were able to process between stopping the video and making a choice therefore this was no longer measuring reaction time but response selection time. At the onset of the study the first button press was intended to act as reaction time but upon consultation (Personal communication; E. Duku, 2019) the recognition and emotion selection phases were combined to create a "response time".

Children with autism tended to respond when the video of the face had completely unblurred before entering a response. This led to all conditions of both emotion and blur to have significant differences based on reaction time which was also consistent with Ukjarevic and Hamilton (2013) who showed that people with autism take longer and make more errors when identifying facial emotional information. Contrary to these findings, Worsham et al. (2015) showed that children with autism may be faster during emotion recognition at the cost of accuracy. When using error as the between group factor in this study there were no significant differences found but participants with autism were more likely to be less accurate during the angry emotion condition. This is consistent with our prediction that children with autism with have more errors during the anger trials, supporting previous studies that points to anger being the most difficult emotion condition to recognize for individuals with ASD (Uljarevic &

Hamilton, 2013). The eyes-first unblurring condition which did find the largest difference of error rates of all blurring conditions consistent with our previous prediction regarding children with autism and eye region aversion (McPartland, Webb, Keehn, & Dawson, 2011).

4.3.a. Future Improvements

The total running time can run from 10-30 minutes which seemed to cause greater stress than any of the other games for all children, regardless of group. The videos could also be altered to end earlier as to challenge the participant to end the task as soon as possible and not allowing the user to become complacent. This increase in drive would be beneficial, as children with autism seem to prefer letting the face completely into focus before stopping video when they recognize the emotion.

4.4. Emotional Stroop Task

The Emotional Stroop task measures the reaction time and accuracy of one's ability to inhibit the automatic processing of emotion words while identifying the emotion displayed on a face. Based on previous studies we predicted that children with autism will have faster reaction times during each condition but having significantly more errors when compared to neurotypically developing controls (Worsham et al., 2015). The control and ASD groups performed similarly when comparing their response time on congruent ($p = 0.421$) and incongruent stimuli ($p = 0.841$). There was an increase in response time for both groups during the incongruent trials, confirming the presence of a Stroop effect. Analyzing the error rates using a Kruskal-Wallis test did not find a significant difference in the error rates on congruent trials between the controls and autism groups ($p=0.07$) but did find a large effect size ($\eta^2 = 0.152$).

As previously predicted a Kruskal-Wallis test did not find significant differences during the positive (p= 0.421) and negative (p = 0.688) emotion stimuli condition when comparing response times. Significant group differences were found comparing error rates during the negative emotion stimuli condition (p = 0.008) reinforcing the results found by Worsham et al. (2015). A Spearman correlation test indicated that there is a positive correlation between group and error rates during the negative emotion condition, (p = 0.029). This follows the previous predictions that while there would be little to no significant difference in response times, error rates would produce the most significant contrasts.

4.4.a. Future Improvements

The Emotional Stroop relies on verbal responses from the children, which is difficult and limiting to a special population such as those with ASD whose symptoms may include difficulties in verbal communication. Another pilot phase with button presses as answers may be of interest to compare with the verbal response time. The timing between each stimulus is the same throughout the task, which may add to testing fatigue or practice effects. To rectify this issue a varied time may be used between the stimuli, so as to add jitter and not allow for any habituation to the task timing.

4.5 McGurk Task

The McGurk Task assesses the ability to combine multiple sources of sensory information to create a holistic experience of the world. When shown the incongruent trial of a person saying "GA GA" but the audio stimulus of "BA BA" a neurotypical mind hears the sound "DA DA". This combination is the effect coined McGurk Effect and is used to measure cross-modal integration of participants. We predicted that those in the ASD group will not be fooled by the incongruent trial and will answer as if hearing the auditory modality. In the current pilot study children with ASD have consistently noted the incongruent trial as "odd" or "weird" but still answer according to the auditory stimuli rather than a combination of multiple percepts. Children with autism identified nearly thirty percent fewer combined percept stimuli than controls when faced with the incongruent McGurk stimuli ($p = 0.533$).

4.5.a. Future Improvements

The task would be more engaging if there were multiple actors making the sounds as to not let the participants become accustomed to a specific person. A broader stimuli set would also be beneficial to the administrator, giving a clearer picture into the performance differences in the population.

Conclusions and Future Directions

5.1 Limitations of Data Analysis

The insufficient amount of completed data sets combined with the small sample size prevented simpler statistical comparisons from being used. Using the averages of each participant per condition of each task allowed for a Kruskal-Wallis comparison of means to be used rather than creating a more complex model that accommodates the completion rates. This made it very difficult to identify any outlier as the nature of error rates make a system or user error indistinguishable from an accurately assessed error by the programs.

5.2 Demographics

The study was not able to test many female participants with autism as well as a control group that was significantly older than the special population participants. We recognize that data from a broader demographic should be used to further refine the CASSA rather than acting as the sole evidence to within the literature on testing performance-based differences.

5.3 Attention and Testing Fatigue

A major factor in the performance of each child, regardless of which group they were in, was the amount of attention required per task. This was made apparent on the Blur-to-Focus Task where the rate of completion among children with autism was significantly lower than that of the control group (10/12 for controls and 6/13 for autism group). This testing fatigue could be mitigated by the reduction in the number of iterations of stimuli within a task needed for a single participant. Each task could improve with added incentives within the games in conjunction with the reduction of trials needed, may motivate children to attend longer.

5.4 Focusing on the strengths of individuals with Autism

The tasks that are collected here are created with the intent to target areas of weakness for individuals with autism within the functional elements of social skills that have been outlined in the literature. To create a more holistic assessment battery it may be advantageous to include tasks that not only target weaknesses but also the various strengths of people with ASD. One brief example is the ability to find a hidden figure as demonstrated by the use of the Embedded figure task by Shah and Firth (1993). The children with autism were superior to their control counterparts at correctly identifying a hidden object embedded within a clock. More recently Caron et al. (2006) found that children with autism have superior speed of locating small objects in a pattern and the discovery of minute changes when comparing two similar pictures (Caron et al. 2006). The Embedded Figure task and the Block design test are both examples where lacking the central coherence drive of a typically developed brain can lead to faster times of recognition and shape building (Caron et al. 2006; Shah and Firth 1993). Other evidence that individuals with autism prefer to focus on the smallest details within the environment has been demonstrated using an optical illusion task where children with autism performed better than controls. In these tasks ASD children tended to focus on small details in the stimuli preventing them from seeing the illusions (Happe, 1996).

5.5 *Conclusions*

The Childhood Autism Social Skills Assessment (CASSA) was created with the intention of being part of a larger comprehensive assessment battery for ASD. A positive diagnosis for autism must include a deficit in social communication abilities. The CASSA was created with five tasks to assess cognitive abilities that children with ASD have performed differently when compared with controls. These underlying cognitive areas include attention, processing preferences, cross-modal integration, theory of mind, and facial emotional identification which all aid in social communication. The current iteration of the CASSA was able to identify statistically significant performance-based differences between controls and our participants with autism. In the future, more robust stimuli sets combined with a larger, age and gender-matched populations will aid in further developing the CASSA to become an important part of an assessment battery.

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APPENDIX A: Letter of Information/Consent Form.

McMaster University
Inspiring Innovation and Discovery

DATE: September 20, 2014

LETTER OF INFORMATION / CONSENT
CHILDHOOD AUTISM SOCIAL SKILLS ASSESSMENT (CASSA) STUDY

Investigators:

Principal Investigator:

Dr.Geoffrey Hall
Department of PNB McMaster University Hamilton, Ontario, Canada (905) 525-9140 ext. 23033 E-mail: hallg@mcmaster.ca

Research Sponsor: Multi Health Systems Inc.

Student Investigator:

Ellis Freedman
Department of PNB McMaster University
Hamilton, Ontario, Canada (905) 525-9140 ext. 24784 E-mail: freedmed@mcmaster.ca

Purpose of the Study: This study is a thesis project developed to develop and evaluate a new computerized Autism Spectrum Disorder assessment. You have been asked to participate because you or your child is between the ages of 5 and 25. We are looking for participants both with and without a diagnosis of Autism Spectrum Disorder.

You and/or your child are invited to take part in this study on the evaluation of a new Autism assessment. We are hoping to learn more about performance-based, computerized assessments. This new assessment provides insight into abilities of children with Autism by interacting with a computer, and also eliminates the bias of typically used observer based interviews and assessments.

What will happen during the study?

You will be asked to come to McMaster University twice to spend 1-2 hours while you or your child will participate in games and/or use a computer as part of a new Autism assessment. I will also ask you for some demographic/background information about your child, such as age and education. After the test, you and/or your child will be asked for some feedback about the tests (How easy is it? How fun is it?).

Are there any risks to doing study?

It is not likely that there will be any harms or discomforts from/associated with this study.
You or your child do not need to answer questions that you do not want to answer, or that make you feel uncomfortable. You or your child can choose to withdraw (stop taking part) at any time. I describe below the steps I am taking to protect your privacy.

Are there any benefits to doing this study?

The research will not benefit you directly. We hope to learn more about Autism assessment and the possibility of using a computerized assessment to aid in the understanding, diagnosis and treatment of Autism Spectrum Disorders.

Payment or Reimbursement

Children will receive a small gift (toy/book) and a gift card for participating in the study. You will be provided with compensation for parking expenses at McMaster University.

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You are participating in this study confidentially. I will not use your name or any information that would allow you to be identified. No one but me (or other members of the research team such as the research assistant) will know whether you participated unless you choose to tell them.

The information/data you provide will be kept in a locked desk/cabinet where only the research team will have access to it. Information kept on a computer will be protected by a password. Once the study has been completed, the data will be shredded and destroyed.

Legally Required Disclosure

Although I will protect your privacy as outlined above, if the law requires it, I will have to reveal certain personal information (e.g., child abuse).

What if I change my mind about being in the study?

Your participation in this study is voluntary. It is your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop (withdraw), at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise. If you do not want to answer some of the questions you do not have to, but you can still be in the study. You can withdraw from this study up until approximately [September, 2015], when I expect to be submitting my thesis.

How do I find out what was learned in this study?

A summary of the results will be posted at www.science.mcmaster.ca/psychology/devneuro/index.html If you would like to receive the summary personally, please let me know how you would like me to send it to you.

Questions about the Study

If you have questions or need more information about the study itself, please contact me at:

freedmed@mcmaster.ca

This study has been reviewed by the McMaster University Research Ethics Board and received ethics clearance. If you have concerns or questions about your rights as a participant or about the way the study is conducted, please contact:

McMaster Research Ethics Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Research Office for Administrative Development and Support E-mail: ethicsoffice@mcmaster.ca

CONSENT

- •□□I have read the information presented in the information letter about a study being conducted by Ellis Freedman and Geoffrey Hall, of McMaster University.
- •□□I have had the opportunity to ask questions about my involvement in this study and to receive additional details I requested.
- •□□I understand that if I agree to participate in this study, I may withdraw from the study at any time or up until approximately September 2015.
- •□□I have been given a copy of this form.
- •□□I agree to participate in the study.

Signature: ______________________________________
Name of Participant (Printed) ___________________________________

Version 1: 20/09/14

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APPENDIX B: Assent form for children under 17 years old.

Assent Form for Minor to Participate
CASSA STUDY
Ellis Freedman, B.A., MSc. Candidate

Your parents are letting me to talk to you about a study that I am working on with a couple of other people. The project is on ***a new computerized Autism Assessment.*** I am going to spend a few minutes telling you about our project, and then I am going to ask you if you are interested in taking part in the project.

Who are we? My name is ***Ellis Freedman*** and I am a **student researcher** at the McMaster University. I work in the Department of ***Psychology, Neuroscience, and Behaviour.***

Why are we meeting with you? We want to tell you about a study that involves children like yourself. We want to see if you would like to be in this study too.

Why are we doing this study? We want to find out if ***this new computerized assessment works for helping assess children in general and children with Autism Spectrum Disorders.***

What will happen to you if you are in the study? If you decide to take part in this study there are some different things we will ask you to do:

- First, I will ask you to *answer some questions about yourself.*
- Second, I will ask you to *play my games.*
- *Third, I will ask you questions about the games (how fun is it? How easy is it?)*
- While doing these things all you have to do is try your best. If you have tried your best and do not know what to say or do next, just say 'I do not know'.
- It will take you about *1-2 hours to do these things.*

Are there good things and bad things about the study? What we find in this study will be used to *help with Autism assessment.* As far as we know, being in this study will not hurt you and it will not make you feel bad.

Will you have to answer all questions and do everything you are asked to do? If we ask you questions that you do not want to answer then tell us you do not want to answers those questions.

If we ask you to do things you do not want to do then tell us that you do not want to do them.

Who will know that you are in the study? The things you say and anything we write about you will not have your name with it, so no one will know they are your answers or the things that you did.

The researchers will not let anyone other than themselves see your answers or any other information about you. Your teachers, principal, and parents will never see the answers you gave or the information we wrote about you.

Do you have to be in the study? You do not have to be in the study. No one will get angry or upset with you if you don't want to do this. Just tell us if you don't want to be in the study.

And remember, if you decide to be in the study but later you change your mind, then you can tell us you do not want to be in the study anymore.

Do you have any questions? You can ask questions at any time. You can ask now or you can ask later. You can talk to me or you can talk to someone else at any time during the study. Here is the telephone number to reach us:

Ellis Freedman, Department of PNB 905-522-1155 x24784

IF YOU WANT TO BE IN THE STUDY, SIGN YOUR NAME ON THE LINE BELOW:

Child's name (Print your name on this line): ____________________________

Date: ___________________________

Signature of the student researcher: ____________________________

Date: ________________________

APPENDIX C: Advertisement

APPENDIX D: Parent Survey

Participant Number:

When did your child receive a diagnosis of Autism Spectrum?

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If your child received any other medical diagnosis, please list them below:

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Please list any medications your child is currently taking:

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APPENDIX E

Before the Handling of Outlier Data

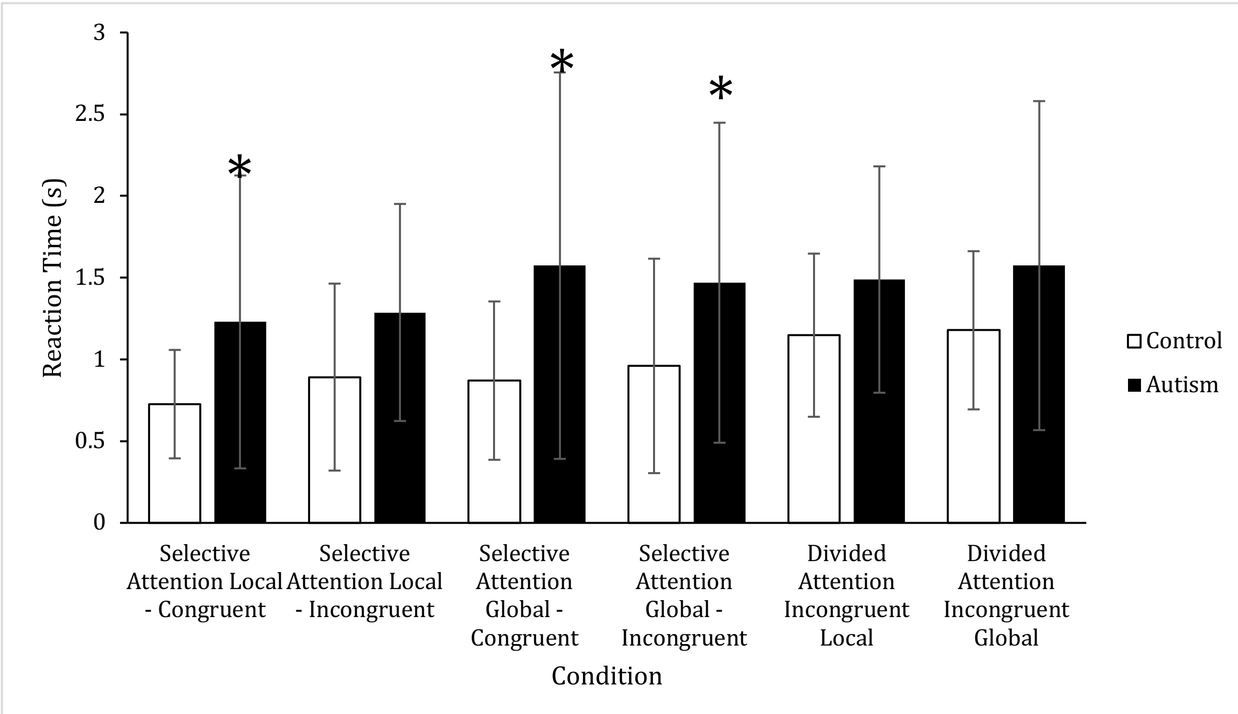

Figure 12. Comparison of reaction time between control (n=11) and Autism (n=13) groups when asked to identify a target appearing at different levels.

Selective Attention Local - Congruent A Kruskal-Wallis test found a significant difference of reaction time between the control (mean = 0.726, sd = 0.331) and autism groups (mean = 1.229, sd = 0.895) during the selective attention local congruent stimuli condition; (H(1) = 3.94, p = 0.047) with a moderate effect size (η^2 = 0.14). A Spearman correlation found a significant positive correlation between group and reaction time (rs (21) = 0.423, p = 0.044).

Selective Attention Local - Incongruent There was no significant difference found using a Kruskal-Wallis test between the control (mean = 0.891, sd = 0.571) and autism group (mean = 1.287, sd = 0.663) using reaction time during the selective attention local incongruent stimuli condition; (H(1) = 4.71, p = 0.03) with a large effect size (η^2 = 0.177). A Spearman correlation found a significant positive correlation between group and reaction time during the selective attention local with incongruent stimuli condition (rs (21) = 0.462, p = 0.026).

Selective Attention Global – Congruent A Kruskal-Wallis test found no significant difference between the control (mean = 0.87, sd = 0.484) and autism group (mean = 1.573, sd = 1.181) during the selective attention global with congruent stimuli condition; (H(1) = 3.46, p = 0.062) with a moderate effect size ($\eta^2 = 0.117$). A Spearman correlation found no significant correlation between group and reaction time during the selective attention global with congruent stimuli (rs (21) = 0.396, p = 0.06).

Selective Attention Global - Incongruent A Kruskal-Wallis test found a significant difference between the control (mean = 0.96, sd = 0.655) and autism group (mean = 1.469, sd = 0.978) during the selective attention global with incongruent stimuli using reaction time; (H(1) = 4.98, p = 0.025) with a large effect size ($\eta^2 = 0.19$). A Spearman correlation found a significant positive correlation between group and reaction time during selective attention global incongruent stimuli condition (rs (21) = 0.475, p = 0.021).

Divided Attention Incongruent Local A Kruskal-Wallis test indicated no significant difference between the control (mean = 1.148, sd = 0.499) and autism group (mean = 1.488, sd = 0.692) during the divided attention with a local incongruent stimuli condition; (H(1) = 1.37, p = 0.242) with a small effect size ($\eta^2 = 0.017$). A Spearman correlation found no significant correlation between group and reaction time during divided attention with incongruent local stimuli (rs (21) = 0.249, p = 0.251).

Divided Attention Incongruent Global There was no significant difference found using a Kruskal-Wallis test between the control (mean = 1.178, sd = 0.483) and autism group (mean = 1.573, sd = 1.006) during the divided attention with a global incongruent stimuli condition; (H(1)

= 0.379, p = 0.538) with a small effect size (η^2 = -0.029). A Spearman correlation found no significant correlation between group and reaction time during the divided attention with stimuli that were incongruent on a global level (rs (21) = 0.131, p = 0.55.

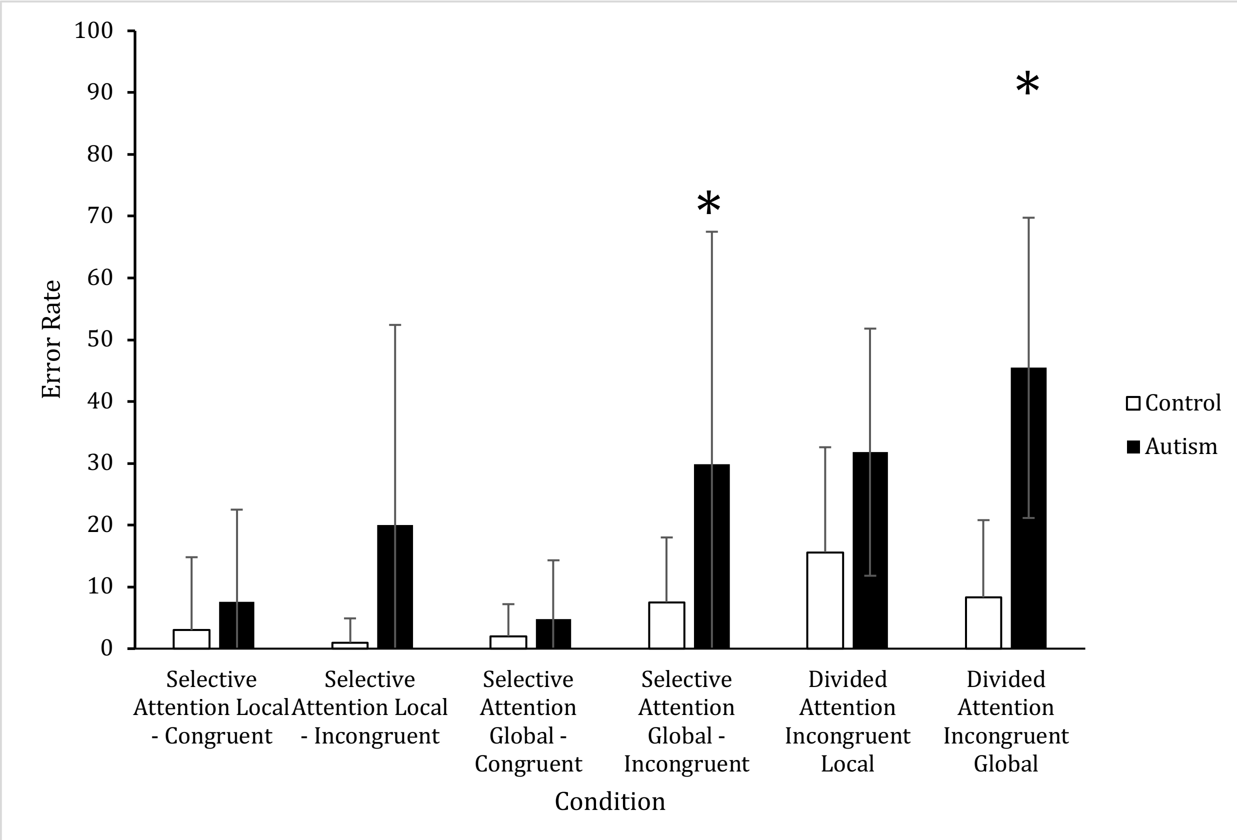

Figure 13. Comparison of error rate between control (n=11) and Autism (n=13) groups when asked to identify a target at different levels of attention.

Selective Attention Local - Congruent A Kruskal-Wallis test found no significant difference between the control (mean = 0.037, sd = 0.118) and autism group (mean = 0.076, sd = 0.149) during the selective attention local congruent stimuli condition; (H(1) = 1.15, p = 0.283) with a small effect size ($\eta^2 = 0.007$). A Spearman correlation found no significant correlation between group and error rate (rs (21) = 0.229, p = 0.293).

Selective Attention Local - Incongruent There was no significant difference found between the control (mean = 0.012, sd = 0.039) and autism groups (mean = 0.201, sd = 0.324) during the selective attention local target with an incongruent stimuli condition using a Kruskal-Wallis test; ($H(1) = 2.71$, $p = 0.099$) with a moderate effect size ($\eta^2 = 0.081$). A Spearman correlation found no significant correlation between group and error rate during this condition ($r_s (21) = 0.351$, $p = 0.101$).

Selective Attention Global – Congruent A Kruskal-Wallis test found no significant difference between the control (mean = 0.025, sd = 0.052) and autism group (mean = 0.048, sd = 0.095) during the selective attention global congruent stimuli condition; ($H(1) = 0.119$, $p = 0.731$) with a small effect size ($\eta^2 = -0.042$). A Spearman correlation found no significant correlation between group and error rate during this condition ($r_s (21) = 0.073$, $p = 0.739$).

Selective Attention Global - Incongruent A Kruskal-Wallis test found no significant difference between the control (mean = 0.075, sd = 0.105) and autism group (mean = 0.298, sd = 0.376) error rates during the selective attention global target with an incongruent stimuli condition; ($H(1) = 2.11$, $p = 0.146$) with a small effect size ($\eta^2 = 0.053$). A Spearman correlation found no significant correlation between group and error rate during this condition ($r_s (21) = 0.309$, $p = 0.15$).

Divided Attention Incongruent Local A Kruskal-Wallis test indicated that no significant difference was found between the control (mean = 0.156, sd = 0.173) and autism group (mean = 0.318, sd = 0.204) during the divided attention with a local incongruent stimuli condition; ($H(1) = 3.04$, $p = 0.081$) with a moderate effect size ($\eta^2 = 0.097$). A Spearman correlation found no significant correlation between group and error rate during this condition ($r_s (21) = 0.371$, $p = 0.08$).

Divided Attention Incongruent Global A Kruskal-Wallis test found a significant difference between the control (mean = 0.083, sd = 0.125) and autism group (mean = 0.454, sd = 0.243) during the divided attention during a global incongruent stimuli condition; ($H(1) = 8.13$, $p = 0.004$) with a large effect size ($\eta^2 = 0.34$). A Spearman correlation found a significant positive correlation between group and error rate during divided attention incongruent global stimuli condition ($r_s(21) = 0.607$, $p = 0.002$).

Blur to Focus

Before the Handling of Outlier Data

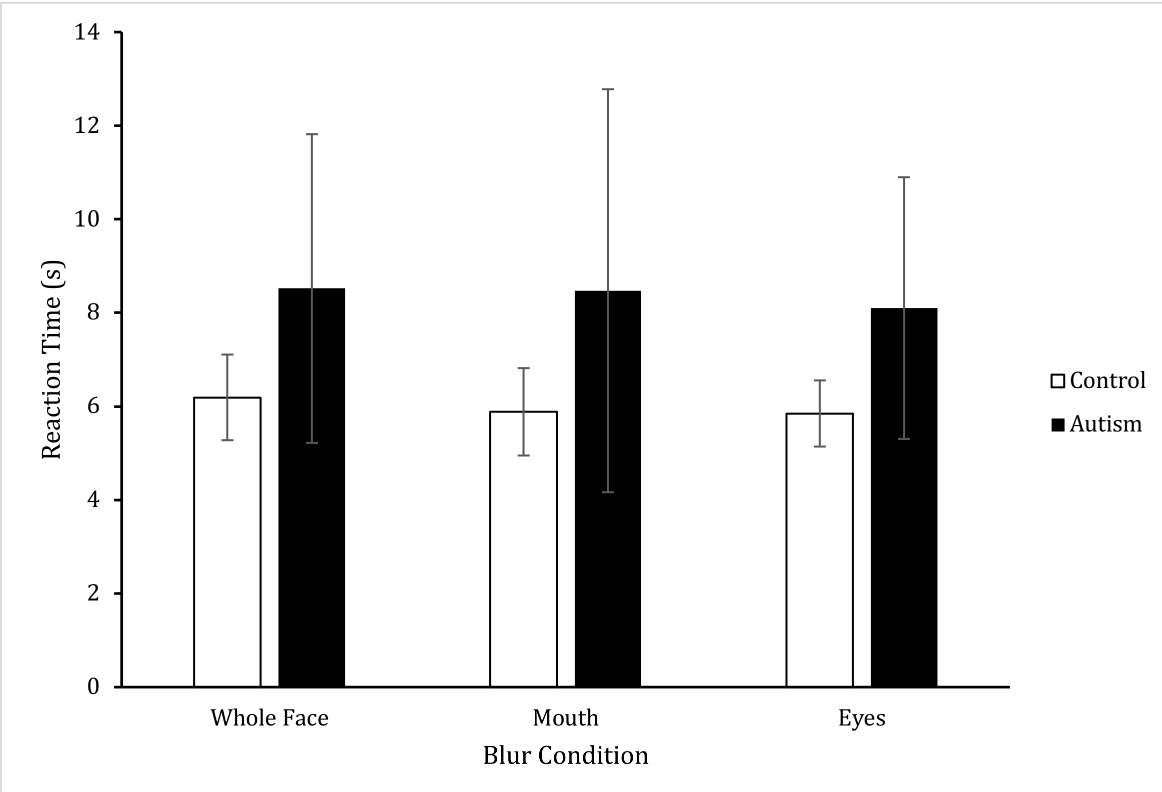

Figure 14. Comparison of response time between control (n=11) and autism (n=9) groups when asked to identify the emotion on an unblurring face. There are three separate ways in which the faces come into focus: whole face, mouth first or eyes first.

Whole Face When the whole face unblurred, controls (mean = 6.192, sd = 0.915) were not significantly faster than the autism group (mean = 8.519, sd = 3.299) as compared by a Kruskal-Wallis test (H(1) = 2.67, p = 0.102) with a moderate effect size (η^2 = 0.092). A Spearman correlation found no significant correlation between group and response time during this condition (rs (18) = 0.37, p = 0.103).

Mouth A Kruskal-Wallis test found no significant difference in response time between controls (mean = 5.884, sd = 0.934) and children with autism (mean = 8.472, sd = 4.306) during the mouth unblurring first condition (H(1) = 3.46, p = 0.062) with a moderate effect size (η^2 = 0.137). A Spearman correlation found no significant correlation between group and response time during this condition (rs (18) = 0.427, p = 0.06).

Eyes A Kruskal-Wallis test found no significant difference in response time between the control (mean = 5.848, sd = 0.707) and autism group (mean = 8.101, sd = 2.796451) during the eyes unblurring condition; (H(1) = 3.46, p = 0.0627) with a moderate effect size (η^2 = 0.137). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18 = 0.427, p = 0.06).

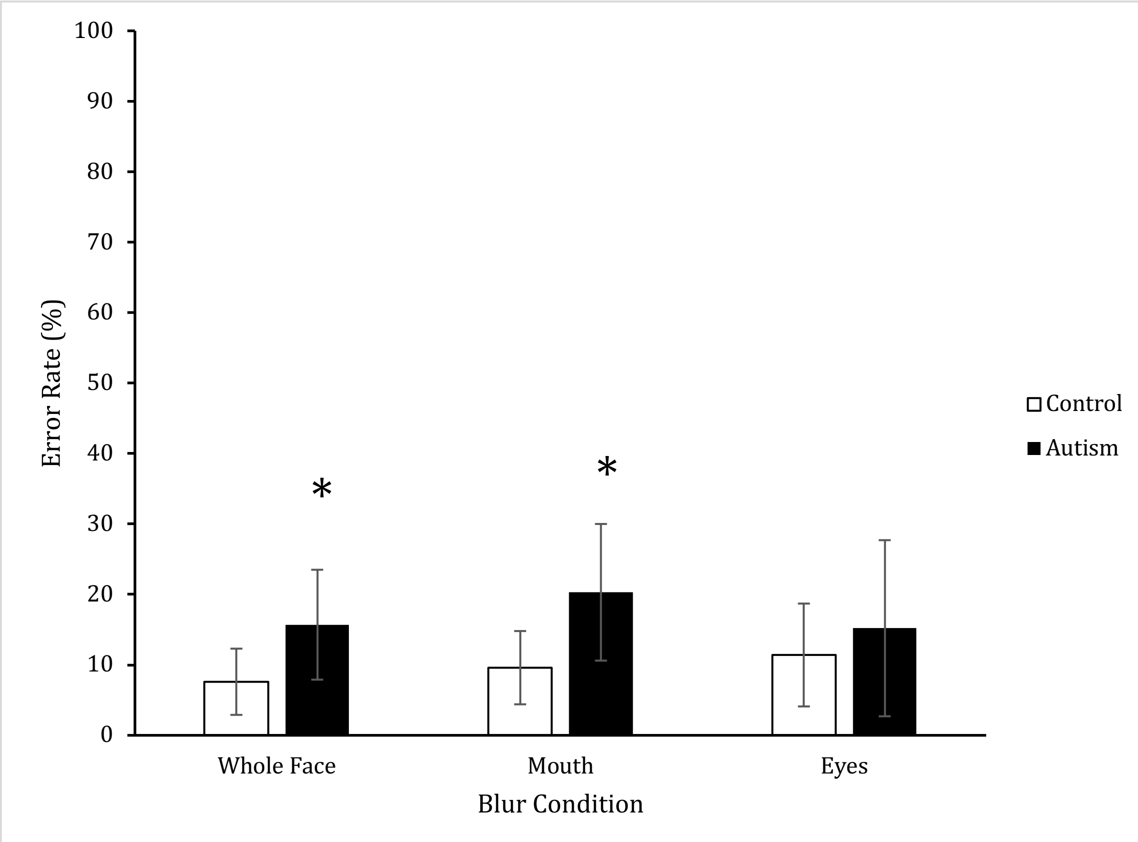

Figure 15. Comparison of three blur conditions using error rates of facial emotion identification between control (n=11) and Autism (n=9) groups. There are three separate ways in which the faces come into focus whole face, mouth first or eyes first.

Whole Face When the whole face unblurred, controls (mean = 0.076, sd = 0.047) were significantly more accurate than the autism group (mean = 0.157, sd = 0.078) using an Independent Samples t-test to compare means (t(18) = -2.826, p = 0.011) with a large effect size (d = -1.27). A Spearman correlation found a positive correlation between group and error rate during the whole face unblurring condition (rs (18) = 0.542, p = 0.013).

Mouth A Kruskal-Wallis test found a significant difference between controls (mean = 0.096, sd = 0.052) and children with autism (mean = 0.203, sd = 0.097) during the mouth unblurring first condition using error rates (H(1) = 7.8, p = 0.005) with a large effect size ($\eta^2 = 0.378$). A

Spearman correlation found a significant positive correlation between group and error rates during the mouth unblurring first condition (rs (18) = 0.64, p = 0.002).

Eyes There was no significant difference found between the control (mean = 0.115, sd = 0.073) and autism group (mean = 0.152, sd = 0.125) comparing error rates during the eyes unblurring condition using a Kruskal-Wallis test; (H(1) = 0.852, p = 0.356) with a small effect size (η^2 = -0.008). A Spearman correlation test found no significant correlation between group and error during this condition (rs (18) = 0.211, p = 0.37).

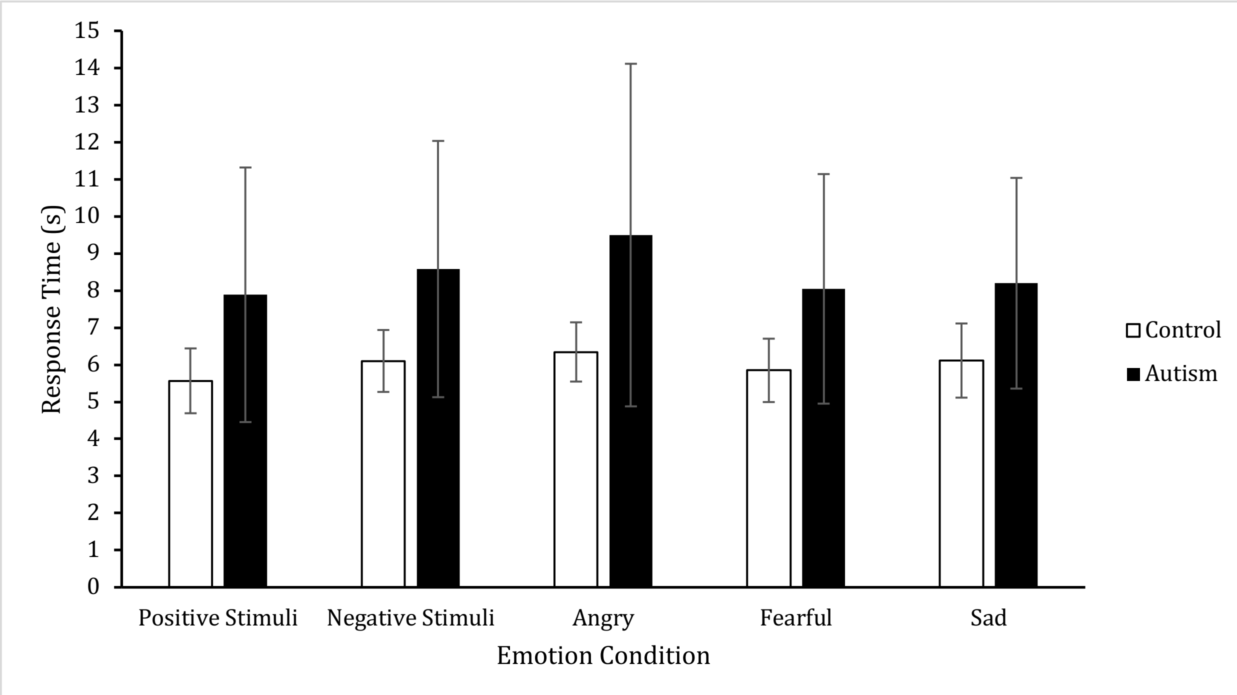

Figure 16. Comparison of response time between control (n=11) and Autism (n=9) groups when asked to identify the facial emotion.

Positive Stimuli There was no significant difference of response times between controls (mean = 5.565, sd = 0.873) and autism (mean = 7.885, sd = 3.431) groups during the positive stimuli condition when compared using a Kruskal-Wallis test ($H(1) = 3.46$, $p = 0.062$) with a moderate effect size ($\eta^2 = 0.137$). A Spearman correlation found no significant correlation between group and performance during this condition ($r_s(18) = 0.427$, $p = 0.06$).

Negative Stimuli A Kruskal-Wallis test found no significant difference between control (mean = 6.101, sd = 0.834) and autism (mean = 8.578, sd = 3.453) groups using their response time during negative stimuli trials ($H(1) = 2.92$, $p = 0.087$), with a moderate effect size ($\eta^2 = 0.107$). A Spearman correlation found no significant correlation between group and performance during this condition ($r_s(18) = 0.392$, $p = 0.087$).

Angry A Kruskal-Wallis test showed no significant difference of response time between controls (mean = 6.344, sd = 0.798) and autism (mean = 9.494, sd = 4.617) groups during the angry condition (H(1) = 2.43, p = 0.119), with a moderate effect size (η^2 = 0.079). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18) = 0.357, p = 0.122).

Fearful A Kruskal-Wallis test found no significant difference between controls (mean = 5.847, sd = 0.854) and the ASD group (mean = 8.044, sd = 3.093) when comparing response time during fearful emotion stimuli (H(1) = 1.39, p = 0.239), with a small effect size (η^2 = 0.021). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18) = 0.27, p = 0.249).

Sad A Kruskal-Wallis test found no significant difference in response time between controls (mean = 6.112, sd = 0.999) and autism (mean = 8.195, sd = 2.839) groups during the sad condition (H(1) = 2.67, p = 0.102) with a moderate effect size (η^2 = 0.092). A Spearman correlation test found no significant correlation between group and performance during this condition (rs (18) = 0. 374, p = 0.103.

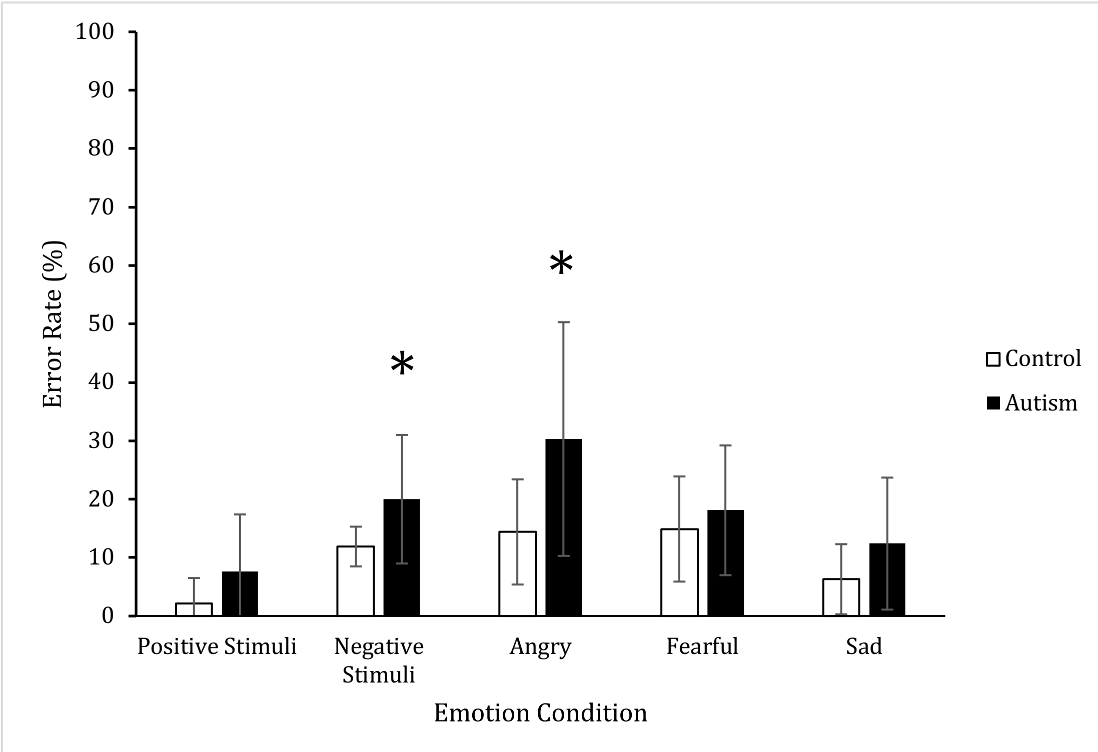

Figure 17. Comparison of error rates of facial emotion identification during different emotion conditions between control (n=11) and Autism (n=9) groups.

Positive Stimuli A Kruskal-Wallis test found no significant difference between controls (mean = 0.022, sd = 0.043) and autism (mean = 0.076, sd = 0.098) groups when comparing error rates during positive stimuli conditions (H(1) = 2.15, p = 0.142), with a moderate effect size (η^2 = 0.064). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18) = 0.336, p = 0.146).

Negative Stimuli A Kruskal-Wallis test found a significant difference between controls (mean = 0.119, sd = 0.034) and autism (mean = 0.203, sd = 0.116) groups using error rates during the negative stimuli condition (H(1) = 3.92, p = 0.047), with a large effect size (η^2 = 0.162). A Spearman correlation found a significant positive correlation between group and error rate during this condition (rs (18) = 0.454, p = 0.044).

Angry There was a significant difference found comparing error rates during the angry emotion condition between controls (mean = 0.144, sd = 0.09) and autism (mean = 0.303, sd = 0.207) using a Kruskal Wallis test (H(1) = 4.57, p = 0.032), with a large effect size ($\eta^2 = 0.198$). A Spearman correlation found a positive correlation between group and error rates during the angry condition (rs (18)= 0.49, p = 0.028).

Fearful A Kruskal-Wallis test found no significant difference between controls (mean = 0.149, sd = 0.09) and autism (mean = 0.181, sd = 0.111) groups when comparing error rates during the fearful condition (H(1) = 0.212, p = 0.645), with a small effect size ($\eta^2 = -0.043$). A Spearman correlation found no significant correlation between group and performance during this condition (rs (18) = 0.105, p = 0.657).

Sad A Kruskal-Wallis test found no significant difference between controls (mean = 0.063, sd = 0.064) and autism (mean = 0.124, sd = 0.113) groups when comparing error rates during the sad emotion condition (H(1) = 1.43, p = 0.233), with a small effect size ($\eta^2 = 0.023$). There was no correlation between error rate during the sad condition and group according to the Spearman correlation (rs (18) = 0.273, p =0.242).

APPENDIX F

Navon Stimuli