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By Carrie Williams

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The Empathizing-Systemizing Theory and Adolescents with Autism Spectrum Conditions

For the degree of Master of Science

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THE EMPATHIZING-SYSTEMIZING THEORY AND ADOLESCENTS WITH AUTISM SPECTRUM CONDITIONS

A Thesis

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ABSTRACT

Williams, Carrie. M.S., Purdue University, May 2012. The Empathizing-Systemizing Theory and Adolescents with Autism Spectrum Conditions. Major Professor: John McGrew.

The empathizing-systemizing (E-S) theory states that individuals with autism spectrum conditions (ASC) can be identified by a deficit in empathy (social skills, communication skills, and theory of mind) and a propensity for systemizing (islets of ability, obsessions with systems, and repetitive behavior). This theory has been tested in various contexts, but never with adolescents between the ages of 12 and 16. The EQ-A (Empathizing Quotient for Adolescents) and the SQ-A (Systemizing Quotient for Adolescents) were administered to 47 adolescents between the ages of 12 and 16 who had been diagnosed with ASC and 97 adolescents with no reported physical or mental disorders to discover differences in empathizing and systemizing.

To test the specific elements and predictions of the E-S theory, the EQ-A was divided into a set of three subscales derived by conceptually mapping items to factors corresponding to the concepts theoretically underlying the scale. The SQ-A was divided into subscales using factor analysis.

It was found that all four subscales resulting from the factor analysis on the SQ-A were associated with obsessions with systems. A weak positive correlation was found

between the SQ-A and the EQ-A. Although the EQ-A was able to differentiate significantly between individuals with an ASC and those without, the SQ-A was not. In addition, although the EQ-A and EQ-A subscales scores correlated with similar subscales scores of the GARS-2 (a well-validated existing autism screening test), the SQ-A and its subscales did not. Implications for the E-S Theory are discussed.

INTRODUCTION

It has been suggested that individuals with autism spectrum conditions (ASC) can be identified by two primary features (Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003; Baron-Cohen, 2004; Baron-Cohen & Belmonte, 2005; Baron-Cohen, 2009) - difficulty mastering social skills and language stemming from an inability to comprehend and provide empathy to others, combined with narrow interests and repetitive behavior. Together, these two features explain most or all of the symptoms recognized in individuals on the autism spectrum, and form the basis for Baron-Cohen's empathizing-systemizing (E-S) theory.

Multiple studies have examined the E-S theory (Baron-Cohen et al., 2003; Wakabayashi, Baron-Cohen, Uchiyama, Yoshida, Kuroda, & Wheelwright, 2007), however only one has used a sample of children (Aeyeung, Wheelwright, Allison, Atkinson, Samarawickrema, & Baron-Cohen, 2009), specifically children ages 4-11 years old. This study examined the empathizing-systemizing theory in adolescents between the ages of 12 and 16 with and without autistic spectrum conditions. It attempted to determine if this theory is still valid in adolescents despite the turbulent influence of puberty, including erratic emotions and bodily changes (Marcotte, Fortin, Potvin, & Papillon, 2002; Blyth & Simmons, 1987). In addition, psychometric properties of the

scales used to test the E-S theory were examined, and implications for the future of the E-S theory were explored.

Mindblindness Theory

The E-S theory developed and evolved over time. One important precursor to the E-S theory is the mindblindness theory. There is now substantial evidence to support the utility of theory of mind, a concept used to understand human cognitive development generally, and now taught in introductory psychology textbooks and scholarly journals alike (Myers, 2004; Baron-Cohen, 1995). In his book *Mindblindness: An Essay on Autism and Theory of Mind*, Baron-Cohen defines theory of mind as knowledge of the mental states of others (1995). For example, if a young child sees that his teacher has taken away a toy from one of his peers, causing him to cry, the young child may infer that his friend is sad and wants his toy back. In this way, we can infer feelings, moods, and social cues by recognizing body posture, facial expressions, tone of voice, and other verbal and nonverbal cues. It allows us to understand when a secret is being kept from us, when we are being ridiculed, or when sarcasm is being employed. It helps us recognize subtleties: a soft nudge to indicate a necessary silence, a covert glance to convey interest. According to Baron-Cohen, although we take these things for granted, most would be lost without theory of mind.

Baron-Cohen outlines four major mechanisms of theory of mind, traces of which can be seen in most children as young as infancy (Baron-Cohen, 1995). However, not all mechanisms are thought to be impaired in those with autism. Although this detailed conceptualization of the components of theory of mind has been researched largely by Baron-Cohen, each of the components is based on evidence from as much as 60 years

ago. The first such mechanism is the *Intentionality Detector* or ID, a perceptual mechanism that interprets motion stimuli of living creatures in terms of basic goals, needs, and desires. This hypothetical mechanism allows us to interpret sensory information from vision, touch, and audition, as well as predict its meaning and possible consequences. Evidence as far back as 1944 (Heider & Simmel) describes this human tendency to anthropomorphize, or ascribe agency to, moving stimuli. For example, Reddy (1991) found that even very young infants are able to detect changes in adults' goals and intentions.

The second mechanism, the *Eye Direction Detector* or EDD, can also be witnessed in the first few months after birth. This hypothetical mechanism detects the presence of eyes and determines whether or not another organism may be looking at us. This mechanism relies on evidence that infants look almost as long at the eyes as at the whole face, and look less at other parts of the face (Hainline, 1978), and look 2 to 3 times longer at a face looking at them than at one looking away (Papousek & Papousek, 1979).

The third mechanism, the *Shared Attention Mechanism*, or SAM, allows us to understand the relationship between ourselves, another person, and a third object or person. This mechanism allows us to have thoughts such as "*My friend and I both see the box*," or, "*The girl behind me can't see the movie screen over my shoulder.*" Baron-Cohen derives this hypothetical mechanism from research on gaze monitoring, or turning in the same direction that another person is looking, suggesting shared visual attention on the same object (Scaife & Bruner, 1975). Gaze monitoring and the pointing gesture have both been observed in infants as young as 9 months (Scaife & Bruner, 1975, Bates et al., 1979).

The fourth mechanism, the *Theory of Mind Mechanism*, or ToMM, is simply the Shared Attention Mechanism's use of the Intentionality Detector and the Eye Direction Detector to infer the feelings and desires of others. In this way, the ToMM uses the information from the Intentionality Detector and the Eye Direction Detector, by way of the Shared Attention Mechanism, to form the process commonly known as theory of mind (Figure 1).

According to Baron-Cohen (1995), a normal infant develops the Intentionality Detector and the basic functions of the Eye Direction Detector within the first nine months, and theory of mind begins to develop at age 4 or 5. Typically, the first sign of theory of mind is marked by a child's engaging in pretend play (such as having make-believe tea parties or talking to a stuffed animal). By the time the infant becomes a toddler, parents of children with autism spectrum conditions have often identified that their child does not socially interact like his or her peers.

Originally, it was thought that children with an autism spectrum disorder lacked theory of mind altogether (Rajendran & Mitchell, 2007). False-belief tests in the 1980's were created to seek out deficits in theory of mind in which the participant watches a sequence of events enacted by dolls or characters in a story (Baron-Cohen, Leslie, & Frith, 1985; Baron-Cohen, 1995; Baron-Cohen, Joliffe, Mortimore, & Robertson, 1997). In it, one doll has a belief about the location of an object that is different from the actual location, and the individual with autism is asked to infer the mental state of the doll ("I think he thinks"). Most individuals with autism were unable to correctly infer the doll's mental state, suggesting that most individuals with autism have a deficit in theory of mind.

Still, researchers worried that this deficit in theory of mind was not universal since some individuals with autism were able to pass these tests (Baron-Cohen, Joliffe, Mortimore, Robertson, 1997). In response, Baron-Cohen and colleagues created second-order theory of mind tests, which required the autistic individual to infer what another person thought about a third person's thoughts (rather than simply inferring what another person thought). Still, 20% of subjects with an autism spectrum disorder passed these false belief tests (Rajendran & Mitchell, 2007). In response, Baron-Cohen suggested that this problem was a delay rather than a deficit.

However, subsequent experiments targeting specifically individuals with Asperger's Syndrome including the strange stories test (Joliffe & Baron-Cohen, 1999), the eyes task (Baron-Cohen et al., 1997), and the Reading the Mind in the Voice test (Rutherford, Baron-Cohen, & Wheelwright, 2002) showed that even these higher-functioning individuals had difficulty interpreting more subtle social cues and/or facial expressions.

One criticism of these advanced theory of mind tests is that they "lack an ingredient essential for diagnosing a representational theory of mind… (they) seem not to be based around the principle that it is vital to test a person's understanding of the causal relationship between informational access and the consequent state of belief" (Rajendran & Mitchell, 2007, p. 229). Instead, "lack of theory of mind" was changed to "mindblindness", averting this requirement. Also, researchers largely changed their focus from *whether* an individual with autism lacked theory of mind to *how much* these individuals were lacking. Despite variations on this theory, "the essential clinical picture that individuals with autism have difficulties understanding both their own and others' mind seems unquestionable" (Rajendran, 2007, p. 231).

Baron-Cohen suggests that the mindblindness common in autism stems from a deficiency in his hypothetical Shared Attention Mechanism, as the Intentionality Detector and Eye Direction Detector functions appear to be normal in individuals with autism spectrum conditions. This claim comes from evidence that individuals with autism are able to use the word "want" in spontaneous speech, and also appear to understand that someone who gets what they want will feel happy whereas someone who does not get what they want will feel sad (Tager-Flusberg, 1993; Baron-Cohen, 1991), suggesting that the ID, at least, remains intact in autistic youngsters. Evidence suggesting that the EDD is also normally functioning in individuals with autism includes studies showing that individuals with autism are able to detect when a person in a photograph is "looking at them" (Baron-Cohen, Capbell, Karmiloff-Smith, Grant, & Walker, 1995). This is also suggested by the fact that individuals with autism interpret eye direction in terms of someone's "seeing" something, and can use the word "see" in spontaneous speech (Tager-Flusberg, 1993; Baron-Cohen, Leslie, & Frith, 1986). In contrast to ID and EDD, there is a large body of research documenting the problems with "joint attention" (children and caregivers sharing attention to objects and events of mutual interest) that is often one of the first signs of autism in children, suggesting a problem with the SAM (Adamson, McArthur, Markov, Dunbar, & Bakeman, 2001; Rogers, 2009; Wetherby, Watt, Morgan, & Shumway, 2007) and consistent with Baron-Cohen's identification of SAM as the critical deficit underlying mindblindness in autism.

However, although there is suggestive evidence that ID and EDD are intact for individuals with autism, the evidence is limited to those with normal or near normal intelligence. As is true with much of the research on cognitive theories of autism,

individuals with mental retardation or who are nonverbal are usually excluded from studies. Moreover, given that those with MR or who are nonverbal are often unable to communicate their own wants and needs, much less those of others, nor are they able to express it if they can detect eye direction, there is some suggestion that the deficiency is located earlier in Baron-Cohen's conceptualization.

This brings into sharp focus a major criticism of the mindblindness theory, the issue of universality, i.e. the degree to which the theory applies to everyone with autism (Rajendran & Mitchell, 2007). No studies exist currently to assess whether nonverbal or barely verbal individuals with autism have or do not have theory of mind. Even if these individuals exhibited some aspects of theory of mind, they would not be able to properly demonstrate this to researchers. Therefore, it is simply unknown whether Baron-Cohen's mindblindness theory applies to individuals who are lower-functioning. This will be discussed later in greater detail.

Baron-Cohen, however, claims that mindblindness is one of the primary symptoms faced by individuals on the autism spectrum in all degrees of severity. For instance, in the earlier example regarding the child and the toy, a non-verbal autistic child may not understand why his peer is crying. This may manifest behaviorally by distress, because he cannot understand, and may consider it confusing or scary. The claim that this reaction reflects mindblindness, however, is based on extrapolation, not on data.

The degree to which mindblindness alone explains the symptoms of autism is arguable (Carruthers, 1996). Mindblindness can explain the lack of empathy and affect commonly displayed in individuals with autism, as well as some aspects of the poor communication and inability to relate to others. In fact, Baron-Cohen and others believe that

mindblindness is at the heart of the deficiencies found in autism (contradicting theories will be discussed later). However, mindblindness fails to completely explain the rigidity and inflexibility of thinking commonly found in autism. Baron-Cohen's more recent empathizing-systemizing theory attempts to complete this explanation.

Empathizing-Systemizing (E-S) Theory

The empathizing-systemizing (E-S) theory elaborates on the mindblindness theory by attempting to explain the symptoms common to the autism spectrum not covered by the mindblindness theory (Baron-Cohen et al., 2003, Baron-Cohen, 2004, Baron-Cohen & Belmonte, 2005, & Baron-Cohen, 2009). The first part of the E-S theory, empathizing, states that individuals with autism share a common deficit in empathy relative to mental age (Baron-Cohen & Belmonte, 2005). Baron-Cohen states that empathy comprises two elements: attribution of mental states to oneself and others as a natural way to make sense of their actions (theory of mind, also called cognitive empathy), and the emotional reactions that are appropriate to others' mental states (affective empathy). In addition, this empathy must be accurately communicated to others to complete a positive social interaction. This lack of empathy seems to manifest in individuals with ASC as a "triad of deficits": social deficits, communication deficits, and deficits in imagining others' minds.

Baron-Cohen adds two additional mechanisms to bridge his original mechanistic conceptualization of theory of mind to the concept of empathizing. The Emotion Detector (TED) represents affective states, and The Empathizing SyStem (TESS) allows an empathic reaction to another's emotional state (Baron-Cohen, 2006; Baron-Cohen,

2005). In theory, these mechanisms complete the concept of empathy and are also either absent or lacking in individuals with ASC (Figure 2).

There has been some criticism regarding confusion with Baron-Cohen's conceptualization of empathizing. It appears that Baron-Cohen is claiming that the Emotion Detector and the Shared Attention Mechanism are defective in individuals with autism, or that there is some delay in these mechanisms (Rajendran & Mitchell, 2007). It also appears that Baron-Cohen is claiming that the various elements discussed above feed into empathizing, while deficits in the Emotion Detector and the Shared Attention Mechanism result in applied delays in theory of mind, socializing, and communication (Baron-Cohen, 2009). However, the specific interconnections among components are only loosely defined. This lack of clarification may be due to an underconceptualization with Baron-Cohen's theory and a lack of empirical data to inform theory. Dr. Bonnie Auyeung, an expert who has worked closely with Baron-Cohen in the past, says "I think more work needs to be done to help clarify the conceptual concepts" (Bonnie Auyeung, personal communication, October 25, 2010).

A lack of empathy is evident in individuals with autism spectrum conditions, ranging from the complete lack of response common in low-functioning individuals to the subtle nuances missed by individuals with Asperger Syndrome. To test this lack of empathy, Baron-Cohen developed the Empathizing Quotient, a forced-answer, self-administered questionnaire that measures individual differences in empathizing (Baron-Cohen & Belmonte, 2005). This test has 60 questions – 40 related to empathizing (including communication, socialization, and theory of mind), and 20 control items (Baron-Cohen et al., 2003). However, the match between scale items and the components in the model is

unclear. Although various items measure both cognitive and affective empathy, subscales have not yet been validated. For example, parent-report items likely assessing theory of mind mechanism (cognitive empathy) include statements such as "My child can easily tell when someone wants to enter a conversation." Items likely assessing the empathizing system (affective empathy) include statements like "My child is very blunt, which some people take to be rudeness, even though this is unintentional." The theory of mind mechanism and empathizing system are not necessarily mutually exclusive, however. Baron-Cohen uses these mechanisms to provide a general break-down of the elements of empathy. Although he suggests that these mechanisms work together to create an empathetic response (or lack thereof in individuals with autism), he does not go into detail on whether these elements correspond directly with items on the EQ and whether they really are separable conceptually.

The EQ has been shown to differentiate individuals with high-functioning autism and Aspergers from their normal counterparts. In a study administered in the United Kingdom (Baron-Cohen et al., 2003), the EQ successfully differentiated a group of 47 adults with Asperger Syndrome/High Functioning Autism (AS/HFA) from a matched control group. Overall, the AS/HFA group scored significantly lower than the control group on the EQ, meaning that individuals with AS/HFA showed significantly less ability to empathize than the control group (t = -8.5, df = 92, p < .0001).

The empathizing half of the E-S theory in particular has been tested successfully across a variety of different cultures and age groups (Wabayashi et al., 2007). Results of the EQ in Japan showed that 48 individuals with ASC scored lower, overall, than 137 general population controls and 1,250 university controls. In another study, 265 children

with ASC scored significantly lower on the EQ-C, a version of the EQ developed for children, than did the groups of typically developing boys and typically developing girls (Auyeung et al., 2009). This lower score suggests a lower drive to empathize than the typically developing individuals, suggesting that the E-S theory is not specific to a single culture or age range. However, in each of these studies, the test was an imperfect predictor of AS/HFA; that is, there was considerable overlap between the groups, again indicating a lack of universality.

The other half of the empathizing-systemizing theory, systemizing, attempts to explain the remaining symptoms commonly identified in individuals with ASC. This part of the theory accounts for what Baron-Cohen conceptualizes as autism's triad of strengths: islets of ability, obsessions with systems, and repetitive behavior (Baron-Cohen & Belmonte, 2005). Baron-Cohen defines systemizing as "the drive to analyze objects and events to understand their structure and to predict their future behavior" (p. 111). Baron-Cohen posits that this ability is either intact or superior in individuals with ASC. (It may be important to note that Baron-Cohen appears to present this triad of strengths as developing separate from the triad of deficits, although undoubtedly these strengths do sometimes help autistic individuals cope with the deficits).

This hypothetical mechanism of systemizing (SM) rests on a few axioms (Baron-Cohen, 2006). First, this mechanism drives the brain to look for input-operation-output relationships in data, and to construct systems. The SM is set at different levels in different individuals, and is determined by each individual's biology. The higher the SM is set, the more the individual will attempt to systemize, and the more they will be attracted to systems with low variance (or change). According to Baron-Cohen, people

with autism have their SM set at the maximum level, which is anywhere from a hypothetical level 5 to level 8. (Note, Baron-Cohen has not yet provided operational definitions for ascertaining a persons' SM level). Individuals with Asperger Syndrome are predicted to have an SM set around level 5, meaning that they can easily systemize totally predictable systems and have great attention to detail, but can also tolerate some change. Individuals with high, medium, and low functioning autism are thought to have an SM of around levels 6, 7, and 8 respectively. Theoretically, the higher the SM is set, the less an individual wants to generalize and deal with change or variance. People with a higher SM will likely become distressed by systems in which there is a great deal of change (such as the social world). These individuals should have the most difficulties with simple false belief tasks which involve theory of mind, but often perform well on systemizing tasks. People with some autistic traits, such as many family members and parents of individuals with autism may exhibit "subclinical" levels, with SMs set at level 4. Typical males are thought to have an SM set at level 3, while typical females have an SM set at approximately level 2. Theoretically, typical individuals with lower SMs are more driven to generalize and can more easily handle change. The level 1 individual has little or no interest or drive to systemize, and so can cope with total change.

Repetitive behavior, obsessions with systems, and islets of ability could then be explained by the autism individual's drive to understand a specific system, be it geological, technical, mathematical, or just a simple childhood toy. A system, says Baron-Cohen, is a predictable input-output relationship that is the same on every trial (Baron-Cohen, 2006). This sameness and predictability is comforting to the autistic individual. Baron-Cohen (2006, p. 870) provides a number of additional examples of this

systemizing behavior which correspond with symptoms commonly observed in individuals on the autism spectrum, including self-stimulation (including rocking or spinning), preoccupation with fixed patterns or structure, need for sameness, tantrums at change, social withdrawal and mindblindness (upon finding that the social world cannot be systemized), narrow interests, immersion in detail, and reduced ability to generalize.

The language delay commonly seen in autism may also be a result of the strong drive to systemize, since language varies each time it is heard (Baron-Cohen, 2006). This may result in echolalia or a monotonous tone, both primitive efforts to systemize language.

Baron-Cohen stresses that according to the Empathizing-Systemizing theory, this extreme drive to systematize can be considered a strength of individuals with autism, as in the case of a computer or mathematical genius whose Asperger's Syndrome spurs them to greater heights of understanding in their field (Baron-Cohen, 2009). He also appears to posit that savantism might be an extrapolation of this drive to systemize, although he is vague on this construct. He says only that "the evidence in relation to superior systemizing includes the fact that some people with autism spectrum conditions have 'islets of ability' in, for example, mathematical calculation, calendrical calculation, syntax acquisition, music or memory for railway timetable information to a precise degree" (Baron-Cohen & Bolton, 1993; Hermelin, 2002; Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003).

However, the drive to construct and adhere to rigid systems also tends to produce a deficit in the ability to accept change. Moreover, the systems constructed by autistic individuals may not be universal, meaning that they may not be understood by or adhered to by the typical individual. This can cause problems when, for example, the typical

individual cannot understand the autistic individual's need to wear certain clothing, follow a certain route to a destination, or eat the same foods repeatedly. In this way, this drive to systemize may be considered a strength or weakness depending on the situation.

It must also be emphasized that having the *drive* to systemize does not necessarily mean that individuals with autism have the *ability* to form the often complex systems of the average mathematician. In individuals with low-functioning autism especially, this drive to systemize may be constrained by mental retardation. Baron-Cohen argues that in these individuals, the drive to systemize is still observable in the tendency to spin or rock repeatedly, tap surfaces, or let sand run through one's fingers (Baron-Cohen, 2009). Above all in his concept of systemizing, Baron-Cohen stresses predictability and repeatability, which are hallmarks of autism (Baron-Cohen, 2003). Systemizing, he says, can be as simple and predictable as "If I push the red button, the projector advances to the next slide."

An individuals' level of systemizing can be tested by the Systemizing Quotient (SQ), another forced-answer test (Baron-Cohen et al., 2003). Like the EQ, the SQ has 20 control questions and 40 questions on systemizing. Males have been found to score significantly higher on the SQ than females in the UK, showing a greater drive to systemize. In addition, adults with Asperger's Syndrome or high-functioning autism were shown to score significantly higher overall than typically developing adults. This trend was also shown to be true in Japan, and with children with ASC (Wakabayashi et al., 2007 & Auyeung et al., 2009).

However, the same problems with universality and specificity that apply to theory of mind can also be applied to the E-S theory. In addition, as noted earlier, several aspects

of theory appear to be underconceptualized (e.g., the interaction between cognitive and emotional empathy). Moreover, there has been little systematic attempt to operationalize hypothesized concepts (e.g., SM levels 1 to 8) or to craft measures with careful attention to content validity (e.g., items and subscales derived to match theoretical constructs) or construct validity (e.g., is there a correlation between SQ and the corresponding specific systems/behaviors that it are supposed to predict, assessed using either self-report or more ideally observationally). There also may be a problem with construct-symptom contamination. That is, it is not clear whether the measures (SQ/EQ) are able to differentiate between the systemizing drive and its resulting symptomatology, which seems confused/confounded. Specifically, it is difficult to determine whether there is a separate drive or if it is just a useful heuristic to understand this constellation of symptoms, i.e., the test seems to be based on the symptoms and from that assumes there is a drive that underlies them. Other problems include the aforementioned concerns that the theory has not been tested across all developmental stages/ages or with those with MR. Further criticisms of Baron-Cohen's E-S theory are provided later on, but some contradicting theories of autism should first be explained.

Contradicting Theories

Baron-Cohen believes that the empathizing-systemizing theory is capable of explaining all symptoms of autism as well as providing a general framework of autism spectrum conditions for diagnosticians. However, it may be illuminating to look at contradictory or corroboratory theories. One such theory, the weak central coherence (WCC) theory, states that individuals with autism have a weakened natural tendency and ability to process information globally (Loth, Gomez, & Happe, 2007). This means that

ASC individuals have difficulty processing information in context and for meaning, instead attending to or remembering local details. Frith (1989) adds that the drive for coherence in autism may be limited, leading to a detailed and systematic processing style.

Evidence in favor of the weak central coherence theory includes studies which have shown that individuals with autism have difficulties in using context to guess the correct pronunciation of homographs (words with one spelling but two pronunciations and two meanings) (Frith & Snowling, 1983; Happe, 1997; Lopez & Leekam, 2003; Rajendran & Mitchell, 2007). This suggests difficulty "reading between the lines", and may explain some of the social difficulties seen in autism. Further studies posit that the weak central coherence, like Baron-Cohen's Empathizing and Systemizing mechanisms, is different in each individual (Jarrold, Butler, Cottington, & Jiminez, 2000).

Proponents of the weak central coherence theory also embrace the idea of theory of mind deficits in ASC individuals but are unclear about the relationship between the two (Loth et al., 2007). For example, some studies show weak central coherence to be present more often in ASC individuals than theory of mind deficits (Happe, 1997), while other studies show a moderate association between the two (Jarrold et al., 2000).

The main difference between the weak central coherence theory and the empathizing-systemizing theory, according to Baron-Cohen, is that while the WCC theory posits that the attention to detail found in ASC individuals is the result of a deficit, the E-S theory argues that it is the result of an accelerated effort to systemize (Baron-Cohen, 2008). Put differently, the WCC sees this tendency to systemize as a negative trait, while the E-S theory claims that this tendency is a potentially positive trait. Real-life examples of individuals with Asperger Syndrome or autism who have put their attention to detail to

good use, such as advanced mathematician Richard Borcherds, would lend support to the idea that systemizing can (at least in some cases) be positive.

The similarities and differences between the E-S theory and the WCC theory are evident in one of the most recent reviews of the weak central coherence theory (Loth et al., 2007). Like Baron-Cohen, Dr. Eva Loth and colleagues imply that weak central coherence (similar to systemizing) and lack of theory of mind (similar to empathizing) are two key symptoms of autism which "are likely to have separate origins." Loth focuses on the way weak central coherence and lack of theory of mind work together to reduce the ability to generalize – the negative side of Baron-Cohen's "drive to systemize." This cooperation between the weak central coherence theory and the theory of mind theory echoes the multiple deficits model, another conceptualization of autism described below.

More recent accounts of the WCC theory have shown some similarities to Baron-Cohen's focus on strengths: for example, rather than a deficit in global processing, researchers are beginning to view the symptoms found in autism as superior local processing (Rajendran & Mitchell, 2007). In addition, the WCC theory has begun to evolve "in such a way that it does not consider people with autism to have either a deficit or dysfunction… rather a cognitive style" (Rajendran & Mitchell, 2007, p. 244).

One major strength of the WCC theory is that it addresses the language deficit commonly seen in autism, however this language deficit (like Baron-Cohen's theory of mind theory) is not universal to all individuals with autism (Lopez & Leekam, 2003; Rajendran & Mitchell, 2007). However, the WCC theory is also limited in that (also like the theory of mind theory) it has difficulty explaining certain aspects of autism, including

the repetitive behaviors such as flapping and spinning, and the prevalence of mental retardation (Rajendran & Mitchell, 2007).

A second alternate theory explaining the symptoms of autism is the executive dysfunction (ED) theory (Ozonoff, Pennington, & Rogers, 1991). The ED theory proposes that the symptoms that Baron-Cohen attributes to an accelerated effort to systemize actually stem from a neural dysfunction, specifically with the brain's frontal lobe (the part of the brain responsible for planning, self-monitoring, and other executive functions) (Hill, 2004). Evidence of this theory includes similarities between autistic individuals and individuals with damage to the frontal lobe, as well as a myriad of studies in which autistic individuals show deficits in areas thought to be connected with the frontal lobe (Ozonoff, Pennington, & Rogers, 1991; Hill, 2004). One major advantage of the ED theory is that it adheres closely to what is already known about the physiology of autism. In addition, the executive dysfunction theory can account for both cognitive and motor (repetitive hand flapping, rocking) characteristics of autism by attributing them to a frontal lobe abnormality (Rajendran et al., 2007). However, as Baron-Cohen points out, the ED theory has even more difficulty explaining instances of advanced understanding of a whole system, such as calendrical calculation, advanced math problems, or perseverations (Baron-Cohen, 2009). In this way, Baron-Cohen again stresses that this tendency to systemize (whether caused by a problem with the frontal lobe, foetal testosterone, or other physiological differences) can be a valuable tool rather than a hindrance.

As with all the theories discussed so far, the ED theory also has problems. For example, it does not necessarily apply to all individuals with autism (universality) or only

to individuals with autism (specificity). Also, the ED theory is multi-faceted, and so it is difficult to measure each aspect in isolation (frontal lobe abnormalities, abnormalities elsewhere, IQ, theory of mind, etc.). There is also debate about whether theory of mind could be fully explained as an executive process.

Which theory most closely resembles the symptoms commonly seen in individuals with ASC? It is important to note that these three theories are not mutually exclusive. All three theories may explain, for example, the teenager with autism or Asperger Syndrome that would prefer to spin in circles, perform the same repetitive movements, or play video games, but then tantrums when a parent attempts to clean his messy room (Baron-Cohen, 2009). The preferred actions of the ASC individual may be due to a weak central coherence, an executive dysfunction, or an accelerated fascination with systems – or all three. The systemizing described by Baron-Cohen may in fact be the positive side of an autistic individual's weak central coherence, which may stem from an executive dysfunction in the frontal lobe. However, the E-S theory additionally suggests that the above mentioned mess in the room may actually be a complex system known only to that individual, who then tantrums due to his inability to tolerate change. Baron-Cohen's E-S theory not only adds the positive spin of "systemizing" to the weak central coherence and executive dysfunction theories; it also accounts for the autistic savants and Asperger's brainiacs, which the other theories do not address.

In another twist, some researchers have considered that autism may be a result of multiple deficits with multiple etiologies, rather than just one (Baron-Cohen & Swettenham, 1997). This may help explain why, after more than 20 years of research, scientists have not yet formed a conceptualization of autism (neither theory of mind, nor

weak central coherence, nor executive dysfunction theory) that can differentiate individuals with autism from those without 100% of the time (Rajendran & Mitchell, 2007). Researchers claim that autistic individuals can be affected differently by impaired theory of mind, weak central coherence, and executive dysfunction (Baron-Cohen & Swettenham, 1997). The three theories may be independent domains that work together to explain the different symptoms associated with autism. The multiple deficit model is an alternate explanation for autism which has the advantage that it ties together all three theories discussed, and helps to explain the lack of specificity or universality for any one of the proposed theories. However, much research is still to be done.

Extreme Male Brain Theory

The extreme male brain theory developed from the E-S theory, and takes root in ideas originally proposed by Hans Asperger (Baron-Cohen, 2008). It is dependent on the validity of the E-S theory, and also the fact that boys tend to score lower on the EQ and higher on the SQ than girls. Therefore, the extreme male brain theory claims that autism and Asperger Syndrome can be seen as an extreme of the typical male profile.

The extreme male brain theory claims that there are 5 different commonly seen 'brain types':

*Type E (E > S) – those whose empathy is stronger than their systemizing

*Type S (S > E) – those whose systemizing is stronger than their empathy

*Type B (S = E) - individuals whose empathy is as good (or as bad) as their systemizing

*Extreme Type E (E >> S) - those whose empathy is above average, but have a challenged grasp of systemizing

*Extreme Type S (S >> E) - those whose systemizing is above average, but have a challenged grasp of empathy.

The extreme male brain theory does not necessarily propose that individuals with ASC have more traditionally male characteristics than do typical individuals, that the rare female with ASC will be more "man-like" than her typical counterparts, or that ASC is strictly a "male problem." It proposes simply that women are more likely to be Type E, men are more likely to be Type S, and ASC individuals are most likely to be Extreme Type S, an extension of Type S. In his book *The Essential Difference: The Truth About the Male and Female Brain*, Baron-Cohen clarifies that while most men have the male brain, some men have the female brain and vice versa; "the central claim… is only that *more* males than females have a brain of type S, and *more* females than males have a brain of type E" (p. 8).

According to one study, the largest group of males (54%) had a Type S brain, and the largest group of females (44%) had a Type E brain (Goldenfeld, Baron-Cohen, & Wheelwright, 2005). The other males were split between Extreme Type S, Type B (or balanced), Type E, and Extreme Type E. In addition, a plurality of people with autism and Asperger Syndrome (47%) had an Extreme Type S brain, an extreme of the male brain. Baron-Cohen has not yet outlined specifically how the various levels of systemizing and the types of brains fit together; however, it is fair to conclude that an individual with a systemizing level 8 is likely to have an Extreme Type S brain whereas an individual with a systemizing level 1 is likely to have an Extreme Type E brain.

The extreme male brain theory is newly developed, and therefore has even more flaws in explanation than does the E-S theory. Specificity and universality are limited, and few

studies have been done to test this theory. Currently, this theory is little more than an elaboration on the E-S theory which itself still requires much research.

The extreme male brain theory does, however, have various implications for the causes of autism.

Implications of the E-S Theory and the Extreme Male Brain Theory for Causes of Autism

Recent information regarding sizes of certain regions of the brain supports the E-S theory and the extreme male brain theory (Baron-Cohen, 2009). This information shows that abnormalities in certain regions of the brain may contribute to autism characteristics. For example, as the extreme male brain theory would predict, regions of the brain such as the superior temporal gyrus, prefrontal cortex, thalamus, and anterior cingulate that are typically smaller in males than in females are even smaller in individuals with autism (Baron-Cohen et al., 2005). In addition, regions that are typically larger in males than in females such as the amygdala, cerebellum, and overall brain size/weight and head circumference are even larger in individuals with autism (Courchesne, Redcay, & Kennedy, 2004; Schumann, Hamstra, Goodlin-Jones, Lotspelch, Kwon, Buonocore, Lammers, Reiss, & Amaral, 2004). The cause of this hypermasculinization is unknown. At least one study has linked it to an increase in foetal testosterone, which has also been shown to correlate with an increase in systemizing preference in children (Auyeung, Baron-Cohen, Chapman, Knickmeyer, Taylor, & Hackett, 2006). In addition to acting as corroborating evidence for the E-S and extreme male brain theories, this information suggests that brain size abnormalities and an increase in foetal testosterone may at least contribute to autism symptoms (Baron-Cohen, 2009). However, this is a relatively new

branch of research, and is only one of many theories of a possible cause of autism. More research must be done to confirm this hypothesis.

Another possible idea that attempts to account for autism symptoms is derived from the suggestion of the E-S theory that the systemizing mechanism is set too high in individuals with autism (Baron-Cohen, 2006). This idea is that autism symptoms may be at least partially a genetic result of the mating of two high systemizers. This may help to explain why, although autism is known to have a genetic influence, some cases of autism have arisen in families with no prior cases of autism. This would also tend to explain the findings that relatives, particularly direct parents, of individuals with autism have higher SMs than the general population (Baron-Cohen et al., 1997; Baron-Cohen, 2006; Happe, Briskman, & Frith, 2003). Like the relation of autism to brain sizes, this theory is relatively new and requires more research.

Issues with and Criticisms of the E-S Theory

Given that the E-S theory and the extreme male brain theory are relatively new developments, criticisms of Baron-Cohen's theory are difficult to find, however, some do exist. Most of the existing criticisms question Baron-Cohen's assertion that females are *naturally* superior at empathizing and males are *naturally* superior at systemizing. Contradicting research argues that the differences which Baron-Cohen and others argue are "innate" are actually a result of social, media, and learned influences (Nash & Grossi, 2007).

In addition, some critics argue that Machiavellianism, which stresses competitiveness and self-interest, is a more natural opposite of empathizing. In fact, Andrew and colleagues claim that Machiavellianism and empathizing show a stronger negative

correlation than empathizing and systemizing and are better able to portray gender differences (Andrew, Cooke, & Muncer, 2008).

A further criticism of the E-S theory is that the scales used to test it measure more than one factor (Andrew, Cooke, & Muncer, 2008). For example, neither Baron-Cohen's assertion that empathizing involves theory of mind (or cognitive empathy) and the Empathizing System (comparable to affective empathy) or his later assertion that the empathizing deficits of autism include social, communication, and theory of mind deficits is tested by the careful and systematic inclusion of items assessing those constructs on the EQ. Dr. Auyeung states, "To date, no subscales have been found" to dissect the E-S theory. One study has attempted a factor analysis on the EQ only, however. In this study, "it was found that some of the items on the emotional reactivity subscale also had high loadings on the cognitive empathy subscale" (Allan, 2009, p. 5; Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004). The present study attempts to form subscales out of the EQ-A based on the ways in which these constructs manifest in individuals with autism (deficits in theory of mind, communication, and social skills).

Another criticism of the E-S theory is that it may not apply to individuals with low-functioning autism, who have thus far not been tested. This echoes the limitation of lack of universality common to all three autism theories (theory of mind, weak central coherence, and executive dysfunction) (Rajendran & Mitchell, 2007). In response to this, Baron-Cohen points out that those suffering from low-functioning or severe autism show a range of symptoms that could be expected if you extrapolate this hypothesized lack of empathizing and accelerated drive to systemize. Specifically, these symptoms include complete apathy to their emotional surroundings coupled with a sharp focus on systems,

such as spinning, rocking (behaviors which provide predictable results), or a special interest. However, this argument is considerably weakened in that it rests on reasoning rather than empirical testing. As stated by Rajendran, the "definition and… theoretical underpinning (of the E-S and theory of mind theories) have yet to be agreed upon, even after 20 years of research" (2007, p. 231).

Although Baron-Cohen's E-S theory theoretically explains what systemizing may look like when seen in an individual with an SM of level 8 (highly repetitive behavior, self-stimulation, tantrums at change, severe language delay, etc.), Baron-Cohen has not yet sufficiently explained why these individuals are nonverbal. It could be that nonverbal autism is simply an even more "severe" version of "severe language delay" (Baron-Cohen, 2006). This would mean that (since spoken language varies every time it is heard) it is so hard for nonverbal individuals with autism to reconcile the spoken language into a system that they can predict that they forgo it altogether. Or, perhaps nonverbal autism may have its own set of causes and theories and may not be explained by the E-S and EMB (Extreme Male Brain) theories. In addition, the language regression displayed by some individuals with autism has not been fully addressed by Baron-Cohen.

Another issue that has not been fully addressed by Baron-Cohen is the IQ of the individuals with autism. Specifically, as noted earlier, testing of not only the E-S theory but of all theories of autism (the theory of mind, weak central coherence, and executive dysfunction theories) have largely ignored the fact that most individuals with autism have IQs below 70 according to Rajendran (2007). Although this impairment is not unique to autism, its prevalence among individuals with autism has not yet been explained satisfactorily. Individuals with IQs less than 40 have traditionally been studied the least,

and some researchers argue that these individuals may score differently on tests of theory of mind. For example, Zelazo, Jacques, Burack, and Frye (2002) found that differences in theory of mind were correlated with individual differences in children with autism who were mildly impaired (IQs between 40 and 70) but this correlation was not found among those who were severely impaired (IQs below 40).

Baron-Cohen claims that "empathy should be testable even in someone with low IQ, for example by using gaze-tracking during an emotional face perception task" (Baron-Cohen, 2009, p. 73), although he does not elaborate on this example. In fact, studies have shown that autistic individuals focus less on the eyes of others than do typical individuals, and that this is positively correlated with a lack of social competence (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). However, this appears to contradict Baron-Cohen's assertion that the Eye Detection Devise is functional in autistic individuals (Baron-Cohen, 1995). Baron-Cohen has not resolved this contradiction. Recently, a study showed that individuals with autism have a decrease that is significantly worse than that of neurotypical individuals in ability to interpret information from the eyes when that region of the face is frozen (Back, Ropar, & Mitchell, 2007). The fact that a decrease was shown suggests that these autistic individuals were reading information from the eyes when they were not frozen, contrary to suggestions that these individuals are completely unable to read facial expressions (Rajendran & Mitchell, 2007). However, the fact that this decrease was significantly worse than with neurotypical individuals corroborates evidence that there is some delay in this area. Perhaps this hypothetical Eye Detection Device is functional, however (as Baron-Cohen suggests) individuals with autism are unable to correctly interpret some or all information gained. Either way, the

lack of clarity of this concept is likely to compromise the utility of a gaze-tracking device to test empathy.

In addition, tests of theory of mind have not claimed to directly and exclusively measure empathy, nor has Baron-Cohen yet attempted such tests of gaze-tracking. Dr. Auyeung says, "Thus far, research with lower functioning individuals is limited due to the difficulties in testing. Also, testing this group is possibly confounded by verbal and learning difficulties, and researchers often cannot be sure of whether the individual is attending to the stimuli and understands instructions for the task. This is why most research in autism has mainly focused on high-functioning individuals or individuals with Asperger's Syndrome" (Bonnie Auyeung, personal communication, October 25, 2010).

Another criticism regarding Baron-Cohen's E-S theory is the question of whether it can really account for the most rudimentary sensory and behavior symptoms of autism such as spinning or rocking. Baron-Cohen attributes these symptoms to an increased drive to systemize, adding that "systemizing should be testable in someone with low IQ by observing if they can detect repetitive patterns (structure) in input" (Baron-Cohen, 2009, p. 73). However, no studies directly linking rudimentary behavior in low-functioning and nonverbal autistic individuals to this increased drive to systemize have yet been attempted.

Although this thesis primarily addresses the E-S theory, one criticism about the extreme male brain theory may be important to note. While the extreme male brain theory may help to explain why some individuals with autism lack an ability to empathize and have a strong ability to systemize, it does not explain individuals whose brains are not the most likely type. For example, 53% of individuals with Asperger's Syndrome

had brains that were not Extreme Type S. It will be important for Baron-Cohen to better explain this deviation from the "usual" brain type in further research.

Adolescent Population

Prior to this study, the E-S theory had been shown to be valid when tested on adults and on children between the ages of 4 and 11 (Auyeung et al., 2009). It had not yet been shown to be valid with adolescents.

When testing the validity of the E-S theory in adolescents, the effects of key issues including adolescent temperament and development must be taken into account. It is well-known that adolescence is a time of changing and growing bodies and minds (Steinberg & Morris, 2001; Marcotte, Fortin, Potvin, & Papillon, 2002; Blyth & Simmons, 1987). During this time, adolescents are faced with new and unfamiliar feelings and changes, and often the main focus of their lives become weathering the emotional ride of puberty. The adolescent population as a whole is known for their tendency to be especially angry, emotional, dramatic, obstreperous, and defiant (Steinberg & Morris, 2001).

Adolescents with autism in particular are likely to be affected by these changes (Steinberg & Morris, 2001; Baron-Cohen, 2009). For a population that is already unfamiliar with social norms and often unable to properly navigate through the world around them, this time must be especially difficult. This study attempted to test Baron-Cohen's theory in the adolescent population to see if these adolescent changes affected any aspects of Baron-Cohen's theory. One possibility was that the symptoms of autism are even more pronounced during adolescence, when hormones are raging and emotions are often high. In this case, the tendency of ASC adolescents to show strong

systematizing drive and low ability to empathize would be especially pronounced. Another possibility was that adolescence would have little effect on the E-S theory, in which case results would be similar to previous studies with other populations.

Purpose of the Current Study

The current study examined the E-S and extreme male brain theories in young people aged 12 to 16 with ASC and a comparison sample of normally developing adolescents. The study adds to the literature in the following ways: (1) Tested whether predictions of the E-S theory and extreme male brain theory generalized to the adolescent age group, (2) Identified sub-dimensions hypothesized to make up the empathizing and systemizing constructs and tested whether these sub-dimensions discriminated between persons with and without autism, (3) Tested hypothesized correlations between the empathizing and systemizing constructs and their sub-dimensions and corresponding symptoms of autism.

The specific research questions are outlined below. Table 1 provides a list of the individual hypotheses. First, it was expected that adolescents with ASC would show generally higher scores on systemizing (SQ-A) and generally lower scores on empathizing (EQ-A) than typically developing adolescents. In addition, it was expected that males would show higher SQ-A scores and lower EQ-A scores than females in both the ASC and normally developing groups, although this was dependent upon how many female subjects with ASC were recruited. These differences between typically developing male and female adolsecents and adolescents in the ASC group, if found, would lend credibility to the E-S theory and to the extreme male brain theory.

In addition, the study attempted to form subscales out of the items on Baron-Cohen's measure of empathizing, the EQ-A (discussed below in measures). A set of three

subscales was derived by conceptually mapping items to factors corresponding to the concepts theoretically underlying the scale. If Baron-Cohen's conceptualization of empathizing is correct, items were predicted to divide into social skills, theory of mind, and communication subscales. Scores on the subscales were predicted to discriminate between adolescents with and without autism. In addition, in both the total sample and within the group of subjects with autism, the EQ-A subscales were predicted to correlate negatively with scores on the SQ-A. Also, an individuals' scores on the various subscales were hypothesized to be predictive of autism severity as assessed by the Gilliam Autism Rating Scale (Second Edition) (GARS-2). Specifically, the scores on the conceptually derived social skills and communication subscales were predicted to correlate positively with the scores on the communication and social interaction subscales on the GARS-2.

A factor analysis was also performed to determine if subscales could be formed from Baron-Cohen's measure of systemizing, the SQ-A. As with the EQ-A subscales, scores on these subscales were predicted to discriminate between adolescents with and without autism. If Baron-Cohen's SQ-A correctly assesses the concept of systematizing, a repetitive behaviors subscale was predicted to emerge from the SQ-A. This subscale was hypothesized to correlate positively with the stereotyped behaviors subscale on the GARS-2 in the group of subjects with autism. Each empirically derived SQ-A subscale also was predicted to correlate negatively with the overall score on the EQ-A.

METHOD

Participants

The study recruited 47 mothers of adolescents with ASC and 97 mothers of typically developing individuals between the ages of 12 and 16. Both verbal and nonverbal individuals with an ASC were included in this study. Demographics were collected including age, grade, and gender of adolescent, average grade received in school, and highest level of education achieved by the mother and father. To be included in the ASC group, parents had to affirm a diagnosis of ASC by a health professional *and* GARS2 scores had to confirm the diagnosis. Adolescents in the TD group were excluded if parents affirmed a medical or psychiatric diagnosis indicating disability (e.g., learning disability, cerebral palsy).

Forty-seven mothers of ASC adolescents were recruited from the internet through autism support groups. Facebook and other support groups joined primarily by spectrum adults or children were targeted, including Autism Speaks and Autism Awareness. Local support groups and autism treatment centers were also targeted such as the Hamilton County Autism Support Group and Autism Awareness Fundraisers & Activities. Mothers were also recruited through autism specialists Dr. Leanne Carlson, PhD, HSPP, and Dr. Maria Valena, MD, both of whom kindly agreed to refer patients with mothers who fit the requirements. Participants were limited to those parents or guardians who

live in the United States, and had children between the ages of 12 and 16. Recruitment fliers are shown in Appendix C.

Ninety-seven mothers of typically developing adolescents between the ages of 12 and 16 were recruited from the website MomsLikeMe.com in Indianapolis, Chicago, Lafayette, Muncie, and Bloomington and from an IUPUI JagNews advertisement for the study. Subjects were limited to those living in the United States. Recruitment fliers are shown in Appendix C.

Measures

Empathizing. The EQ-A is a 40 item scale intended to measure empathizing as defined by Baron-Cohen (Baron-Cohen, 2009; Baron-Cohen & Wheelwright, 2004). It has been recently adapted from the EQ for use with adolescents between the ages of 12 and 16 by the Autism Research Centre (Bonnie Auyeung, personal communication, April 29, 2010). This measure has not yet been used in a published study, but was obtained through personal communication with the author.

The original EQ has been shown to have predictive validity and to be reliable (Baron-Cohen & Wheelwright, 2004). It has been shown to correlate negatively with symptoms of autism as measured by the AQ ($r = -0.48$, $p < 0.001$), or Autism Spectrum Quotient. In addition, the EQ has been shown to have very good internal consistency (Cronbach's alpha .92). It has also been shown to have concurrent validity, displaying a moderate correlation with the Interpersonal Reactivity Index (IRI), a similar measure of empathy (Davis, 1980). Psychometrics for the EQ-A have not yet been established.

For the EQ-A, a 'slightly agree' response scores one point and 'strongly agree' scores two points on items indicating high empathizing ability; all other responses score zero

points. For reverse coded items, a response of 'slightly disagree' scores one point and a score of 'strongly disagree' scores two points. Scores on the EQ-A range from 0 to a maximum of 80.

A set of subscales was created by the first author based on an examination of content validity of EQ-A items. (Although a previous set of subscales was created for the EQ by Lawrence and colleages (2004), the questions were slightly different than those used for the EQ-A, and so these subscales could not be used.) Each item was designated as falling under 'communication', 'social interaction', and 'theory of mind' based on the items' content.

Systemizing. The SQ-A is a 55 item scale intended to measure systemizing as defined by Baron-Cohen (Baron-Cohen et al. 2003). It has been adapted from the SQ for use with adolescents between the age of 12 and 16 (Dr. Bonnie Auyeung, personal communication, April 29, 2010). It has not yet been used in a published study.

The original SQ has been shown to have predictive validity and to be reliable (Baron-Cohen & Wheelwright, 2004; Baron-Cohen et al. 2003). The SQ correlates positively with the AQ ($r = 0.46$, $p < 0.002$), suggesting that the SQ can help to explain an individual's location on the autism spectrum. In addition, the SQ has been shown to have adequate internal consistency (Cronbach's alpha of .79). Psychometrics for the SQ-A have not yet been established.

For the SQ-A, a 'slightly agree' response scores one point and a 'strongly agree' response scores two points on items indicating high systemizability. For reverse coded items, a response of 'slightly disagree' scores one point and a response of 'strongly disagree' scores two points. Scores on the SQ-C range from 0 to a maximum of 110.

Minor changes in wording were made by the investigator to the EQ-A and SQ-A to make them consistent with language and cultural norms for the United States rather than the UK. (e.g. "ticking the box" was changed to "checking the box").

Autism Diagnosis/Screen. The Gilliam Autism Rating Scale (Second Edition) (GARS-2) is a 42-item scale intended to determine whether an individual has an autism spectrum disorder and, if so, an individuals' severity on the autism spectrum (Gilliam, 2006). Subscales are included for Communication, Social Interaction, and Stereotypical Behaviors. Each item is rated along a 4 point Likert scale ranging from 0 ("Never Observed") to 3 ("Frequently Observed"). Scores of 85 or higher on the Autism Index suggest that an individual is likely to have autism. Scores of 70 to 84 indicate that the individual may have autism, and scores at or below 69 imply that the individual is not likely to have autism.

The GARS-2 has good internal consistency: Cronbach's alphas for the subscales range from .70 to .90 (Gilliam, 2006). The GARS-2 showed evidence of concurrent validity with the Autism Behavior Checklist (ABC). Correlations between GARS-2 subscales and parallel subscales on the ABC ranged from .56 (correlation of the GARS-2 Social Interaction subscale and the ABC Social Self-Help scale) to .78 (correlation of the GARS-2 Stereotyped Behaviors subscale and ABC Body/Object Use subscale), suggesting high convergent validity.

Procedure

Questionnaires were sent over the internet using the SurveyMonkey website. The primary investigator recruited eligible mothers through the above mentioned support

groups, companies, websites, and specialists. Respondents who replied that they would complete the survey were emailed the survey link.

Analysis

Data collected was transferred directly from the SurveyMonkey website to an SPSS database located on a secure computer. Surveys were imported electronically. Raw data was checked for outliers and missing values. General descriptive data including mean, standard deviation, and frequency was determined. The internal consistency of the total scale and subscale for each measure was calculated for the obtained sample. Effect sizes were determined and reported.

For Hypothesis 1a, adolescents with ASC were predicted to have lower scores on the EQ-A and EQ-A subscales and higher scores on the SQ-A and SQ-A subscales than typically developing adolescents. This was tested using t-tests. For Hypothesis 1b, expected results included a weak negative correlation between the overall EQ-A and the overall SQ-A. A Pearson correlation was used to test this.

For Hypothesis 2, the SQ-A items were predicted to load onto three separate subscales (obsessions with systems, islets of ability, and repetitive behaviors). This was examined using an exploratory factor analysis. There was an insufficient sample size to use confirmatory factor analysis.

For Hypothesis 3, scores on the total SQ-A and the SQ-A repetitive behaviors subscale were predicted to correlate positively with scores on the stereotyped behaviors scale on the Gilliam Autism Rating Scale (Second Edition), as tested by Pearson correlation.

For Hypothesis 4, scores on the total EQ-A and the EQ-A communication and social skills (conceptually derived) subscales were predicted to correlate negatively with scores on the communication and social interaction scales on the Gilliam Autism Rating Scale (Second Edition). This was tested by using Pearson correlation.

The exploratory hypothesis tested for gender differences with the total sample and separately within subgroups (ASC and TD) using a 2X2 ANOVA. Boys and ASC individuals were predicted to have relatively low scores on the EQ-A total scale and subscales and relatively high scores on the SQ-A total scale and subscales, while girls and normally developing individuals were predicted to have relatively high scores on the EQ-A scales and relatively low scores on the SQ-A scales. Two main effects and no interactions were predicted.

RESULTS

Subjects

A total of 198 individuals attempted the survey, and 163 completed the survey. Of these individuals, 47 claimed to have a child with some sort of autism spectrum condition ranging from mild Asperger's Syndrome to autism. However, only 14 of these children also met the minimum GARS-2 criteria for autism (scores > 70). There were 97 parents in the typically developing group, all of whom reported having a child aged 12 to 16 with no medical problems. Nineteen parents were excluded because they reported that their child had some other neurological disorder, especially ADHD.

Table 2a and Table 2b display demographic information about the parents and children for the total sample and for the typically developing group, the parent report ASC group and the GARS-2 defined ASC groups. The typically developing and parent report ASC groups displayed significant differences on several dimensions (Table 2a). Compared to children in the typically developing group, those in the parent-report ASC group were more likely to be in special education (12.8% vs. 1.0%; $\chi^2 = 9.427$, $p < .002$) or a generally lower grade ($t = -2.063$, df = 135, $p < .041$), were less likely to receive A grades (23.4% vs. 42.3%; $\chi^2 = 31.1$, $p < .001$), and were more likely to be male (78.7% vs. 52.6%; $\chi^2 = 9.1$, $p < .003$).

There was a discrepancy between parent report of ASC and GARS-2 confirmed diagnosis of ASC. Surprisingly, most of the parent defined ASC group (71.2%) did not meet GARS-2 criteria for ASC. As is shown in Figure 3, GARS-2 scores were skewed slightly to the left, with the rest of the scores distributed fairly evenly for both males and females. Accordingly, we repeat analyses for both the parent defined ASC group and the GARS-2 defined ASC group.

When using GARS-2 defined ASC, similar differences were found between the typically developing group and the GARS-2 defined ASC group (Table 2b). Compared to children in the typically developing group, those in the GARS-2 ASC group were more likely to be in special education (21.4% vs. 1.0%; $\chi^2 = 14.663$, $p \leq .001$), were less likely to receive A grades (23.1% vs. 42.3%; $\chi^2 = 42.5$, $p < .001$), and were more likely to be male (78.6% vs. 52.6%, $\chi^2 = 3.4$, $p \leq .067$). In addition, despite these nearly identical means (13.89 vs. 13.86), compared to the typically developing group, those in the GARS-2 defined group were much more likely to be enrolled in a lower grade level (M = 5.86 (3.6) vs. M = 7.82 (1.8), $t = -3.25$, df = 109, $p < .001$). Mothers and fathers reported similar educational backgrounds.

Descriptive Statistics

Table 3 displays the mean and standard deviations for the EQ-A and SQ-A and subscales for the ASC and TD groups.

Internal Consistency

Cronbach's alpha coefficients were calculated for the EQ-A, the SQ-A, and the GARS-2 (see Table 3). In addition, Cronbach's alpha coefficients were calculated for the three contrived subscales of the EQ-A (Communication, Social Skills, and Theory of

Mind) and the three subcales of the GARS-2 (Stereotyped Behaviors, Communication, and Social Interaction), also shown in Table 3. The internal consistency coefficients were acceptable for all scales and subscales (> .70) except for the EQ-A Communications subscale (.69) and the EQ-A Social Skills subscale (.60).

Hypotheses

Hypotheses were tested and results are presented below using both the parent report and GARS-2 identified ASC groups.

As predicted for Hypothesis 1a, compared to typically developing adolescents, those with parent- reported ASC scored higher on the EQ-A total score (16.7 vs. 39.3, $t(142) = -9.21$, $p < .001$, effect size = -1.55) and on the social, communication, and theory of mind subscales (see Table 3). In contrast, those with parent-reported ASC scored similarly to typically developing adolescents on the SQ-A total score (36.9 vs. 37.2, $t(142) = -.12$, $p = .90$, effect size = -.02) and on its empirically derived subscales.

A similar pattern of results was obtained using the GARS-2 defined ASC group. Individuals with GARS-2 defined ASC still differed significantly from the typically developing adolescents on the EQ-A (17.9 vs. 39.3, $t(109) = -5.01$, $p < .001$, effect size = -.96) and scored similarly to typically developing adolescents on the SQ-A (37.6 vs. 37.2, $t(109) = .071$, $p = .943$, effect size = 0.01).

Hypothesis 1b was tested by a Pearson correlation. The analysis was repeated within each of four samples: for the total sample, restricted to the ASC sample (both the GARS-2-defined and parent-report-defined ASC group) and restricted to the typically developing group. Correlations between scales and subscales for the total sample are shown in Table 4. The EQ-A and the SQ-A showed a weak positive correlation across

the total sample, $r = .242$, $p < .001$. A similar positive correlation was found when restricted to either the typically developing sample, $r = .389$, $p < .001$, or the parent-report-defined ASC sample, which was nearly significant, $r = .286$, $p < .051$. When restricted to GARS-2-defined ASC sample only, the EQ-A and the SQ-A showed a much stronger positive correlation, $r = .724$, $p < .004$.

An exploratory factor analysis was conducted to determine if SQ-A subscales could be extracted that aligned with those predicted in Hypothesis 2 (Table 5). A principal components factor analysis was used. An oblique rotation was selected. SQ-A items initially loaded onto 17 different factors with eigenvalues greater than 1. Examination of the scree plot revealed that a solution with four factors would be satisfactory (see Figure 4). However, because three factors were hypothesized as consistent with Baron-Cohen's original E-S theory (Baron-Cohen, 2009), analyses were rerun forcing both a four factor and a three factor solution. Ultimately, the SQ-A items loaded best onto 4 different factors in the exploratory analysis, as more items failed to load onto a 3-factor matrix with the oblique rotation. Table 5 shows the various loadings. Factor loadings below .4 are not shown.

The first subscale contained mainly items related to organizing objects, such as "My adolescent likes music or book shops because they are clearly organized" and "If my child had a collection (e.g., CDs, coins, stamps), it would be highly organized." The second subscale contained mainly items dealing with collections or construction of items, such as "When my child looks at a bridge s/he does not think about how precisely it was made" and "My child is a collector (e.g., of books, coins, etc)." The third subscale contained mainly items dealing with the organizing of language and information, such as

"When my child reads something, s/he always notices whether it is grammatically correct" and "When my child learns a language, s/he becomes intrigued by its grammatical rules." Last, the fourth subscale contained mainly items dealing with the organization of events and maps, such as "My child finds it very easy to use bus schedules, even if this involves several connections" and "My child does not tend to remember people's birthdays (in terms of which day and month this falls." The only item that did not load onto the four factors was item #25, "At school, my child does not carefully file all his/her work." It should be noted that there was considerable overlap in the item loadings, such that almost all of the items loaded on multiple factors.

These four derived subscales – Organization, Collections/Construction, Language & Information, and Events & Maps – did not map onto the three hypothesized factors. Instead all of the subscales mapped onto the obsessions with systems factor. That is, there was no clearcut differentiation in item theme. In addition, the alpha for the entire SQ (.905) was higher than the alpha for all four scales (.788, .817, .762, and .629), and was at a level consistent with a unidimensional scale. Given the good internal consistency of the total scale and the lack of a factor structure consistent with theory or demonstrating clear conceptual differentiation, the SQ-A was treated as a unidimensional single scale for the remaining analyses.

Hypothesis 3 tested criterion validity of the SQ-A against the corresponding GARS-2 subscale. In contrast to the prediction, the correlation between SQ-A scores and the GARS-2 stereotyped behaviors subscales was not significant when tested with the total sample (see Table 6), the parent-defined ASC sample (r = .103, p = .490), or the GARS-2 defined ASC sample (r = -.112, p = .702).

Hypothesis 4 tested criterion validity of the EQ-A communication and social skills subscales against the corresponding GARS-2 communication and social interaction subscales. As expected, using the total sample, there were significant correlations between the EQ-A communication subscale and the GARS-2 communication subscale (r = -.469, p < .001) and between the EQ-A social skills subscale and the GARS-2 social interaction subscale (r = -.634, p < .001). The correlations between these items when restricted to the parent-defined ASC sample only were not significant (see Table 6). However, when restricted to the GARS-2 defined sample, the GARS-2 social interaction subscale correlated positively with the EQ-A social skills subscale, r = .586, p = .028 and the correlation between the GARS-2 communication and EQ-A communication subscales also was nearly significant, (r = -.477, p = .085).

For the exploratory hypothesis, an ANOVA was conducted to see if there were differences between male and female individuals with and without an ASC on the EQ-A and the SQ-A. The analyses were done twice, first using the parent-reported ASC group and second using the GARS-2 defined ASC group. Using the parent-reported ASC group, the ASC group scored lower than the typically developing group on the EQ-A mirroring the predictions from Hypothesis 1, and confirming the significant difference between groups (f(1) = 55.7, p < .001). The main effect for gender also was found; males scored significantly lower than females on the EQ-A (f(1) = 6.0, p = .016, M = 15.24 vs. M = 22.30) On the SQ-A, the main effect for the ASC versus typically developing group was not significant, however the main effect for gender showed a significant difference between groups (f(1) = 15.6, p < .001, with males again scoring lower than females (M = 32.11 vs. M = 54.40). However, the interpretation of the main effect was complicated by

a significant group by gender interaction on the SQ-A ($f(1) = 7.8$, $p < .007$). Although parent-reported ASC boys scored slightly lower than typically developing boys, which is in the direction predicted, parent-reported ASC girls scored much *higher* than typically developing girls, which is in a direction opposite from what was predicted (M = 54.40 vs. M = 39.22). Means and standard deviations are shown in Table 7. The interaction is shown in Figure 5.

When analyses were repeated restricted to the GARS-2 ASC defined group, ASC boys scored significantly lower than ASC girls on both the EQ-A score (M = 13.09 vs. M = 35.67; $f(1) = 8.826$, $p < .077$) and on the SQ-A score (M = 28.64 vs. M = 70.33; $f(1) = 16.533$, $p < .001$. As before, there was a significant interaction effect ($f(1) = 11.5$, $p < .002$). However, because there were only 11 males and 3 females in the ASC group, interpreting the interaction is problematic.

DISCUSSION

The main goal of this thesis was to test whether adolescents showed the expected pattern of results predicted by the E-S theory, as has been obtained in earlier studies, with children and adult populations. Individuals with an ASC were expected to score low on the EQ-A, a test of empathizing, and high on the SQ-A, a measure of systemizing (Hypothesis 1). In addition, the EQ-A and SQ-A were predicted to be weakly negatively correlated, because individuals with ASCs are thought to be high on systemizing and low on empathizing (vice versa for the typically developing subjects).

This thesis also examined the construct validity of the SQ-A and EQ-A to see if the SQ-A factored into the concepts Baron-Cohen proposed when defining systemizing – Repetitive Behaviors, Islets of Ability, and Obsessions with Systems (Hypothesis 2) – and whether the subscales of the EQ-A and SQ-A correlated positively with similar subscales on the GARS-2 (Hypothesis 3 and 4).

The results for the EQ-A supported the E-S theory. Individuals with ASC scored lower on the EQ-A and its subscales than did typically developing individuals. Moreover, the EQ-A was able to differentiate, as expected, between males and females. In addition, the scale factored into three conceptually derived subscales reflecting the three areas of empathizing proposed by Baron-Cohen, and the subscales correlated as predicted with similar subscales on the GARS-2, providing evidence for criterion

validity. Moreover, the subscales and total scale had adequate internal consistency reliability, providing support for the general psychometric properties of the scales. These results suggest that the EQ-A, at least, accurately reflects Baron-Cohen's empathizing facet of autism and provides support for the empathizing aspect of autism in an adolescent sample.

In contrast, the SQ-A failed to support the E-S theory. The SQ-A was unable to distinguish between typically developing individuals and ASC individuals, and in contrast to predictions, showed a weak positive correlation with the EQ-A. Moreover, the scale did not contain elements consistent with the constructs and subscales predicted by Baron-Cohen, nor did it correlate positively with similar scales on the GARS-2, as predicted. Although the SQ-A was able to differentiate between males and females, in contrast to predictions, the results showed that females systematize more than males. One possible explanation is that many items on the SQ-A failed to assess behaviors relevant to autism. When selected SQ-A items were examined that were particularly relevant to autism (such as "My adolescent does not find it distressing if people who live with him/her upset her routines"), they tended to show the differences expected (higher systematizing in the ASC spectrum population). Further research is needed to identify items that represent systematizing as a construct, focus on behaviors relevant to ASC and discriminate between those with and without ASC.

In addition, the EQ-A and SQ-A showed a positive correlation, although this correlation was significant only when restricted to the GARS-2 ASC sample. This finding is in stark contrast to those of Auyeung et al., (2009) when the EQ and SQ were

tested with children, who reported a small negative correlation between the EQ and SQ only in the total sample.

There are several possible reasons for these findings. One concern is that the SQ-A is a new scale that has not been validated with the adolescent group, thus, the results may reflect problems with scale validity in this group. Prior studies with the SQ were able to differentiate between the typically developing and ASC groups (Baron-Cohen et al, 2003; Baron-Cohen, 2009). A related concern is that Baron-Cohen's scale only appears to test the obsessions with systems facet of systemizing, rather than all three facets. These concerns could mean that the SQ-A is a poorly constructed measure that fails to adequately measure systemizing as proposed within the E-S theory and thus cannot provide a good test of the E-S theory. Alternatively, it could be that Baron-Cohen's conceptualization of autism has weak construct validity, meaning that the E-S theory may not be able to properly define autism.

One difficulty with interpreting the results is that the parent defined ASC group included few persons with verifiable ASC. In fact, GARS-2 diagnosis could be confirmed in only 14 of the 47 adolescents (29.8%). Thus, it is not clear whether results using the parent defined ASC group constitute a fair or valid test of the hypotheses. Although in some cases the results were similar using parent defined and GARS-2 defined ASC groups, in other cases the results were quite different. For example, one important difference between the two samples was a much stronger positive correlation between the EQ-A and the SQ-A scores in the GARS-2 ASC sample when a weak negative correlation was predicted, further questioning Baron-Cohen's theory. However, it is unclear whether this is evidence for poor construct validity, or variation due to small

sample size. Similarly, the predicted positive correlation between the GARS-2 social interaction subscale and the EQ-A social skills subscale was found only in the GARS-2 ASC sample. Again, this may be chance variation due to sample size or positive evidence for construct validity

Implications

This study has several implications for the E-S Theory. First, the results with respect to the empathizing part of the E-S theory suggest that Baron-Cohen is making positive strides toward conceptualizing the empathizing deficits in autism and fully supports Baron-Cohen's work in this area. The fact that the EQ-A was able to differentiate between the typically developing group and either ASC sample, had good internal consistency, and divided into Baron-Cohen's hypothesized subscales (which correlated with the similar GARS-2 subscales) supports Baron-Cohen's research on theory of mind, the various mechanisms responsible for empathizing, and the empathizing part of the E-S theory. Importantly, these results have now been shown with child, adult, and now adolescent populations.

The theory begins to unravel, according to this study, when systemizing is brought into the mix. One main flaw is that Baron-Cohen's SQ-A does not break down into the three proposed areas, obsessions with systems, repetitive behaviors, and islets of ability subscales. Although Baron-Cohen's E-S theory may be accurate, until the SQ scale or some similar scale is shown to reliably test all three subscales, at best the theory can only be partially validated and at worst, not validated at all. Clearly more work is needed to develop a construct valid measure of systemizing.

Regarding the extreme male brain theory, this study cannot fully support Baron-Cohen's research claiming that autism is an elaboration of the male brain. Although the ANOVA showed significant differences between males and females on both the empathizing and systemizing scales, the systemizing scale could not differentiate between subjects with and without an ASC except when limited to the GARS-2 defined sample and the differences between males and females was in the opposite direction to that predicted by the theory (males systemized less in this sample). Therefore, this study fails to provide support for the EMB theory.

Limitations

This study suffered from several limitations. The small sample size was a methodological weakness (underpowered), as well as the fact that this study used self-report measures largely administered online. The sample obtained online may have been different (e.g. volunteers, more interested in research, etc.) than a sample obtained in a different manner. To counteract this, the primary investigator attempted to obtain as many subjects as possible from local autism treatment facilities such as Damar, however, this was only partially successful. In addition, Baron-Cohen's EQ-A and SQ-A have not yet been validated, and have never been used with adolescents. Shortly before proposing, Dr. Auyeung informed the primary investigator that a study with adolescents is currently taking place in England, and reliability and validity information will be available soon.

Construct validity may have also been compromised, because Baron-Cohen's EQ subscales are not distinct and have already been shown to have some overlap when factor analyzed in a previous study (Allan, 2009; Lawrence, Shaw, Baker, Baron-Cohen, &

David, 2004). The SQ may also have difficulty with construct validity, as the SQ-A was unable to be divided into Baron-Cohen's predicted constructs when factor analyzed.

In addition, various parts of Baron-Cohen's E-S theory lack a solid operational definition, as explained in the literature review, which may further decrease construct validity. There are flaws in his definitions of the various mechanisms that make up empathizing, which he has not yet clarified. In addition, Baron-Cohen's definition of "systemizing" as made up of repetitive movement, islets of ability, and obsessions with systems is not reflected in his SQ scale.

A serious limitation was the small sample size. One cannot usually expect to make solid conclusions with a sample size of 144 subjects. Another major limitation of this study is the wide range of phenotypic expression in the ASC sample, ranging from Asperger's Syndrome to full-blown autism.

Another serious limitation was the reliance on parent self-report of ASC diagnosis. When verified using the GARS-2, less than 30% fit the criteria using the most generous cut score. Thus, the sample size of those with ASC was even more limiting than the overall sample.

CONCLUSION

Baron-Cohen's Empathizing Systemizing (E-S) theory was tested on a sample of adolescents between the ages of 12 – 16. It was not possible to make a definitive test of the E-S theory. Although the theory may be valid, the SQ-A or Systemizing Quotient for Adolescents may not be a valid measure of systemizing. The SQ-A could not differentiate between the ASC and typically developing adolescents, nor did it correlate as predicted with the EQ-A. Accordingly, the study was unable to robustly test the systemizing aspect of the E-S theory. The EQ-A, however, was able to differentiate between ASC and typically developing adolescents, and subdivided into subscales corresponding to the postulated factors underlying empathizing, and correlated as predicted with similar subscales on the GARS-2. That is, the current results provided support for the empathizing aspect of the E-S theory. Future research is required to develop a more reliable and valid measure of systemizing with the adolescent population. Moreover, further research is needed using larger sample sizes and using ASC samples that meet rigorous diagnostic criteria.

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TABLES

Table 1

Hypotheses of Empathizing-Systemizing Theory with Adolescents Thesis

Hypotheses Number	Hypotheses
Hypothesis 1	a. Compared to typical adolescents, those with an autism spectrum conditions will have lower scores on the EQ-A, and higher scores on the SQ-A. • Adolescents with ASC will have lower overall scores on the EQ-A and higher overall scores on the SQ-A. • Adolescents with ASC will have lower scores on the EQ-A subscales and higher scores on the SQ-A subscales. b. The EQ-A and the SQ-A will show a weak negative correlation, meaning that individuals with ASD have lower scores on the EQ-A and higher scores on the SQ-A, and typically developing individuals have higher scores on the EQ-A and lower scores on the SQ-A.
Hypothesis 2	The SQ-A items will load onto three separate subscales (obsessions with systems, islets of ability, and repetitive behaviors).
Hypothesis 3	Scores on the total SQ-A and the SQ-A repetitive behaviors subscale will correlate positively with scores on the stereotyped behaviors scale on the Gilliam Autism Rating Scale (Second Edition). This will be tested both for the total sample and when limited to the ASC sample.
Hypothesis 4	Scores on the total EQ-A and the EQ-A communication and social skills (conceptually derived) subscales will correlate negatively with scores on the communication and social interaction scales on the Gilliam Autism Rating Scale (Second Edition). This will be tested both for the total sample and when limited to the ASC sample.
Exploratory Hypothesis:	Overall, males will have lower scores on the EQ-A total scale and subscales and higher scores on the SQ-A total scale and subscales than females. Males with ASC will have the lowest EQ-A scores and the highest SQ-A scores, while females without ASC will have the highest EQ-A scores and the lowest SQ-A scores.

Table 2a

Demographic Characteristics, total sample

	Typically Developing	ASC	All Participants	Analysis (TD vs. ASC)
Age	M = 13.89 SD = 1.406	M = 13.51, SD = 1.196	M = 13.76 SD = 1.348	t = -1.57, df = 141, p < .091.
Male * Female *	51 (52.6%) 46 (47.4%)	37 (78.7%) 10 (21.3%)	88 (61.1%) 56 (38.9%)	x^2 = 9.1, p < .003
Grade Level: Special Education vs. Other Grades* All Other Grades	1 (1.0%) M = 7.90 (8th grade) SD = 1.689	6 (12.8%) M = 7.20 (7th grade) SD = 2.10	7 (4.9%) M = 7.36 (7th grade) SD = 2.304	x^2 = 9.427, p < .002 t = -2.063, df = 135, p < .041
Mostly As * Mostly Bs * Mostly Cs *	41 (42.3%) 33 (34.0%) 17 (17.5%)	11 (23.4%) 13 (27.7%) 7 (14.9%)	52 (36.1%) 46 (31.9%) 24 (16.7%)	x^2 = 31.1, p < .001
Father with 4-year education Father with at least a 2-year degree Father with less than college degree	20 (20.6%) 46 (47.4%) 51 (52.6%)	18 (38.3%) 29 (61.8%) 18 (38.3%)	38 (26.4%) 75 (52.1%) 69 (47.9%)	x^2 = 12.3, p = .092
Mother with 4-year education Mother with at least a 2-year degree Mother with less than college degree	32 (33.0%) 65 (67.1%) 31 (32.0%)	15 (31.9%) 32 (68.0%) 15 (31.9%)	47 (32.6%) 97 (67.4%) 46 (31.9%)	x^2 = 4.9, p = .558

Note: Significant differences are represented with *.
Note: n = 144
Note: ASC = Autism Spectrum Condition
TD = Typically Developing

Table 2b

Demographic Characteristics, GARS-2 defined sample

	Typically Developing	ASC	All Participants	Analysis (TD vs. ASC)
Age	M = 13.89 SD = 1.406	M = 13.86 SD = 1.406	M = 13.88 SD = 1.399	t = -.070, df = 108, p = .798
Male * Female *	51 (52.6%) 46 (47.4%)	11 (78.6%) 3 (21.4%)	62 (55.9%) 49 (44.1%)	x^2 = 3.4, p = .067
Grade Level: Special Education vs. Other Grades* All Other Grades*	1 (1.0%) M = 7.82 (8th grade) SD = 1.820	3 (21.4%) M = 5.86 (6th grade) SD = 3.613	4 (3.6%) M = 7.58 SD = 2.206	x^2 = 14.663, p < .001 t = -3.253, df = 109, p < .001
Mostly As * Mostly Bs * Mostly Cs *	41 (42.3%) 33 (34.0%) 17 (17.5%)	3 (23.1%) 3 (23.1%) 1 (7.7%)	44 (40.4%) 36 (33.0%) 18 (16.5%)	x^2= 42.5, p < .001
Father with 4-year education Father with at least a 2-year degree Father with less than college degree	20 (20.6%) 46 (47.4%) 51 (52.6%)	8 (57.1%) 8 (57.1%) 6 (42.9%)	47 (42.3%) 54 (48.6%) 57 (51.3%)	x^2 = 7.3, p = .296
Mother with 4-year education Mother with at least a 2-year degree Mother with less than college degree	32 (33.0%) 65 (67.1%) 31 (32.0%)	10 (71.5%) 12 (85.8%) 2 (14.2%)	66 (60.0%) 77 (70.0%) 33 (30.0%)	x^2 = 3.8, p = .577

Note: Significant differences are represented with *.
Note: n = 111
Note: ASC = Autism Spectrum Condition
TD = Typically Developing

Table 3

Descriptive Statistics for EQ, SQ, and GARS-2 total and subscale scores (Mean and Standard Deviation of Scales)

Scale (ICC)	Total Mean (SD)	ASC Mean (SD)	TD Mean (SD)	ASC vs. TD T-test (p-value)	GARS-2 Defined ASC Mean (SD)	GARS-2 vs. TD T-test (p-value)
EQ-A-total (.949)	32.0 (17.4)	16.8 (10.0)	39.3 (15.3)	-9.2 (.000)	17.9 (11.8)	-5.0 (.000)
EQ-A Social (.604)	7.7 (3.1)	5.1 (2.8)	8.9 (2.5)	-8.2 (.000)	5.4 (2.7)	-5.0 (.000)
EQ-A Comm (.685)	5.6 (3.8)	2.9 (2.7)	6.9 (3.6)	-6.7 (.000)	3.7 (3.4)	-3.1 (.002)
EQ-A TOM (.945)	17.1 (11.5)	7.6 (6.3)	21.8 (10.6)	-8.5 (.000)	7.9 (7.9)	-4.7 (.000)
SQ-A (.905)	37.1 (16.9)	36.9 (20.8)	37.2 (14.7)	-.1 (.903)	37.6 (30.9)	.07 (.943)
GARS-2 (.971)	25.4 (26.5)	54.9 (22.2)	11.1 (13.3)	14.8 (.000)	81.2 (6.8)	19.4 (.000)
GARS-2 SB (.898)	8.3 (8.4)	16.8 (7.8)	4.1 (4.7)	12.1 (.000)	24.3 (5.4)	14.7 (.000)
GARS-2 Comm (.923)	7.2 (8.9)	16.7 (8.7)	2.6 (3.8)	13.5 (.000)	26.6 (4.8)	21.2 (.000)
GARS-2 Social (.948)	9.9 (10.6)	21.3 (8.6)	4.4 (5.8)	13.7 (.000)	30.4 (4.9)	15.9 (.000)

Note: $n = 144$

Note: ASC = Autism Spectrum Condition
TD = Typically Developing
SD = Standard Deviation
EQ-A = Empathizing Quotient for Adolescents
Comm = Communication
TOM = Theory of Mind
SQ-A = Systemizing Quotient for Adolescents
GARS-2 = Gilliam Autism Rating Scale 2
SB = Stereotypic Behavior

Table 4

Correlations and p Values (in parenthesis) using total sample – Hypothesis 1

	EQ-A	EQ-TOM	EQ-Comm	EQ-Social	SQ-A	GARS-2	GARS-2 SB	GARS-2 Comm	GARS-2 Social
EQ-A	1								
EQ-TOM	.981 (.000)	1							
EQ-Comm	.848 (.000)	.770 (.000)	1						
EQ-Social	.824 (.000)	.746 (.000)	.614 (.000)	1					
SQ-A	.242 (.001)	.292 (.000)	.114 (.173)	.259 (.002)	1				
GARS-2	-.650 (.000)	-.610 (.000)	-.518 (.000)	-.638 (.000)	.073 .382	1			
GARS-2 SB	-.620 (.000)	-.589 (.000)	-.497 (.000)	-.576 (.000)	.060 (.475)	.936 (.000)	1		
GARS-2 Comm	-.603 (.000)	-.562 (.000)	-.469 (.000)	-.606 (.000)	.024 (.772)	.954 (.000)	.839 (.000)	1	
GARS-2 Social	-.632 (.000)	-.590 (.000)	-.510 (.000)	-.634 (.000)	.116 (.166)	.964 (.000)	.847 (.000)	.885 (.000)	1

Note: $n = 144$

Note: EQ-A = Empathizing Quotient for Adolescents
Comm = Communication
TOM = Theory of Mind
SQ-A = Systemizing Quotient for Adolescents
GARS-2 = Gilliam Autism Rating Scale 2
SB = Stereotypic Behavior

Table 5

Eigenvalues and weights of SQ-A Factors

Items on SQ-A	Factor 1	Factor 2	Factor 3	Factor 4
Eigen value	10.161	4.335	2.876	2.250
Weight of factors				
1 Easy to use bus schedules		.531		
2 Likes music or book shops	.452	.439		
3 Not enjoy organizing events		.471		
4 Notices grammatically correct				-.407
5 Categorizes people into types				
6 Difficult to read maps			.428	
7 Looks at how bridge was made	.480			
8 Difficult to learn video games			.465	
9 Collects examples of objects				
10 Intrigued by language rules				-.410
11 Details of weather forecast	.415			
12 Highly organized collection	.462	.408		
13 Curious about building construction	.436			
14 Not interested in wireless communication	.493			
15 Enjoys comparing products	.578			
16 Good at understanding money		.523		
17 Did not enjoy collecting sets	.415			
18 Interested in family tree	.431			
19 Does not focus on dates	.550			
20 Does not enjoy strategy games	.493		.436	
21 Understanding details in categories	.619			
22 Is not distressing to upset routine			-.407	
23 Likes to know animal species	.494			
24 Remember information about interesting topic	.493			
25 Does not carefully file work		.527		
26 Fascinated by how machines work	.559			
27 Does not notice furniture construction details	.427			
28 Does not try to work out rules in social situations				
29 Does not watch & read science	.506			
30 Gives directions to parts of town				
31 Does not think about painting techniques	.448			
32 Prefers structured social interactions				

33 Interested in river paths	.657			
34 Is collector	.498			
35 Clothes not carefully organized				.445
36 Rarely reads about new technology	.559			
37 Does not enjoy learning history facts	.575			
38 Does not remember birthdays		.550		
39 Curious about how trees differ	.518			
40 Looks into lens quality in cameras	.446			
41 Wants to know exact computer qualities	.438			
42 Does not follow system when tidying room	.415	.412		
43 Wants to know precise features of stereo	.509			
44 Keeps everything just in case				
45 Avoids uncontrollable situations				
46 Does not care to know names of plants	.592			
47 Not interested in weather patterns	.537			
48 Does not bother if things are not in place	.421			.507
49 Intrigued by number rules & patterns	.488			
50 Difficult to learn way around new city				
51 Could list favorite 10 books	.455			
52 Prefers to read fiction				
53 Likes to plan shopping in order	.424		-.451	
54 Notices music structure	.403			
55 Could make list of favorite 10 songs from memory				

Table 6

Correlations and p Values – Hypothesis 3& 4

Scale Comparison	Sample R (p-value)		
	Total (n = 144)	Parent-Report ASC (n = 47)	GARS-2 Defined ASC (n = 14)
SQ-A vs. GARS-2 Stereotypical Behaviors Subscale	0.06 (p = .475)	0.103 (p = .49)	-0.112 (p = .702)
EQ-A Communication Subscale vs. GARS-2 Communication Subscale	-0.469 (p = .000)	0.025 (p = .865)	-0.477 (p = .085)
EQ-A Social Skills Subscale vs. GARS-2 Social Interaction Subscale	-0.634 (p = .000)	-0.224 (p = .13)	0.586 (p = .028)

Note: SQ-A = Systemizing Quotient for Adolescents
EQ-A = Empathizing Quotient for Adolescents
GARS-2 = Gilliam Autism Rating Scale

Table 7

ANOVA Means & Standard Deviations for neurotypical and ASC groups by gender for EQ-A and SQ-A

Group	EQ-A Mean	EQ-A Standard Dev.	SQ-A Mean	SQ-A Standard Dev.
Typical Group (*n* = 97)	39.32	15.295	37.22	14.719
Typical Boys (*n* = 51)	36.225	15.006	35.41	13.546
Typical Girls (*n* = 46)	42.75	15.033	39.22	15.828
ASC Group (*n* = 47)	16.745	9.977	36.85	20.758
ASC Boys (*n* = 37)	15.243	8.46	32.11	16.648
ASC Girls (*n* = 10)	22.300	13.375	54.4	25.674
ASC GARS-2 Defined Group (n = 14)	17.929	11.841	37.57	30.924
ASC GARS-2 Defined Boys (n = 11)	13.091	7.133	28.64	21.639
ASC GARS-2 Defined Girls (n = 3)	35.667	7.506	70.33	42.724

Note: ASC = Autism Spectrum Condition
EQ-A = Empathizing Quotient for Adolescents
SQ-A = Systemizing Quotient for Adolescents
GARS-2 = Gilliam Autism Rating Scale

Table 8

ANOVA F and p Value for neurotypical and ASC groups for EQ-A and SQ-A

Dependent Variable	ASC Group	Main Effects		Interaction Effect
		ASC group vs. TD group F, p-value, partial eta square	Gender F, p-value, partial eta square	Gender X group F, p-value, partial eta square
EQ-A	Parent report ASC	F(1) = 55.7, p = .000, $\acute{\eta}^2$ = .076	F(1) = 6.0, p = .016, $\acute{\eta}^2$ = .041	F(1) = 0.0, p = .924, $\acute{\eta}^2$ = .000
	GARS-2 ASC	F(1) = 9.5, p = .003, $\acute{\eta}^2$ = .080	F(1) = 8.8, p = .004, $\acute{\eta}^2$ = .076	F(1) = 2.7, p = .104, $\acute{\eta}^2$ = .024
SQ-A	Parent report ASC	F(1) $\acute{\eta}^2$ = 3.2, p = .075, $\acute{\eta}^2$ = .023	F(1) = 15.6, p = .000, $\acute{\eta}^2$ = .100	F(1) = 7.8, p = .006, $\acute{\eta}^2$ = .053
	GARS-2 ASC	F(1) = 4.7, p = .032, $\acute{\eta}^2$ = .042	F(1) = 16.5, p = .000, $\acute{\eta}^2$ = .134	F(1) = 11.5, p = .001, $\acute{\eta}^2$ = .097

Note: EQ-A = Empathizing Quotient for Adolescents
SQ-A = Systemizing Quotient for Adolescents
GARS-2 = Gilliam Autism Rating Scale
ASC = Autism Spectrum Condition
TD = Typically Developing

FIGURES

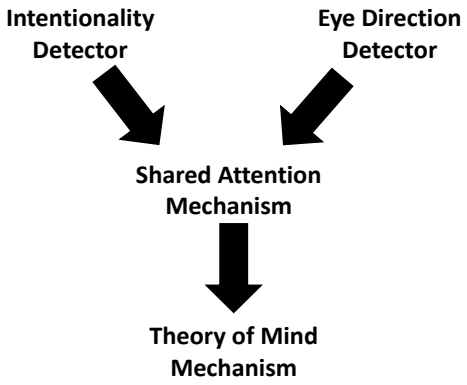


Figure 1

Theory of Mind Mechanism

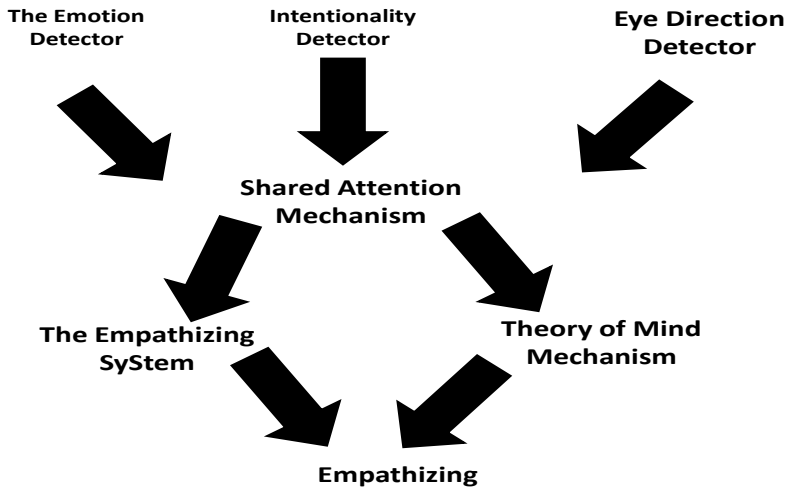
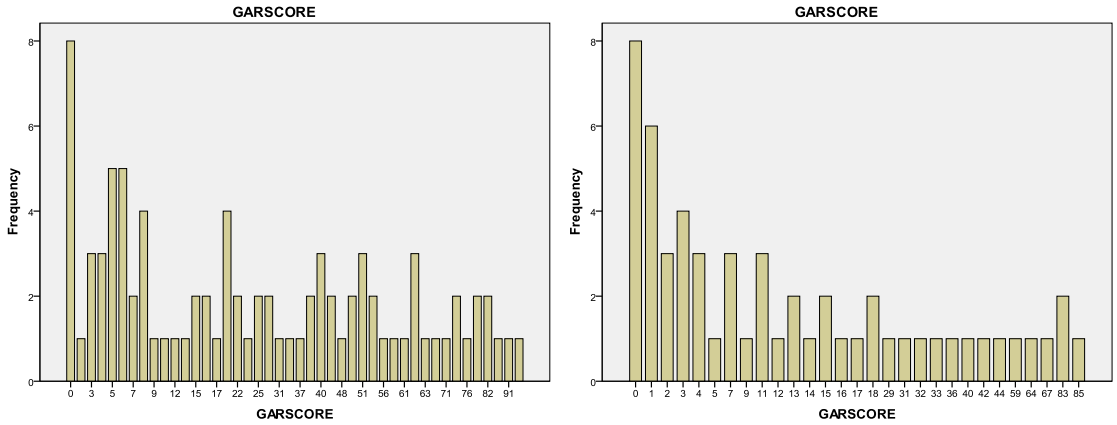


Figure 2

Empathizing-Systemizing Theory



Males Females

Figure 3

Frequency of GARS-2 Scores for Males and Females

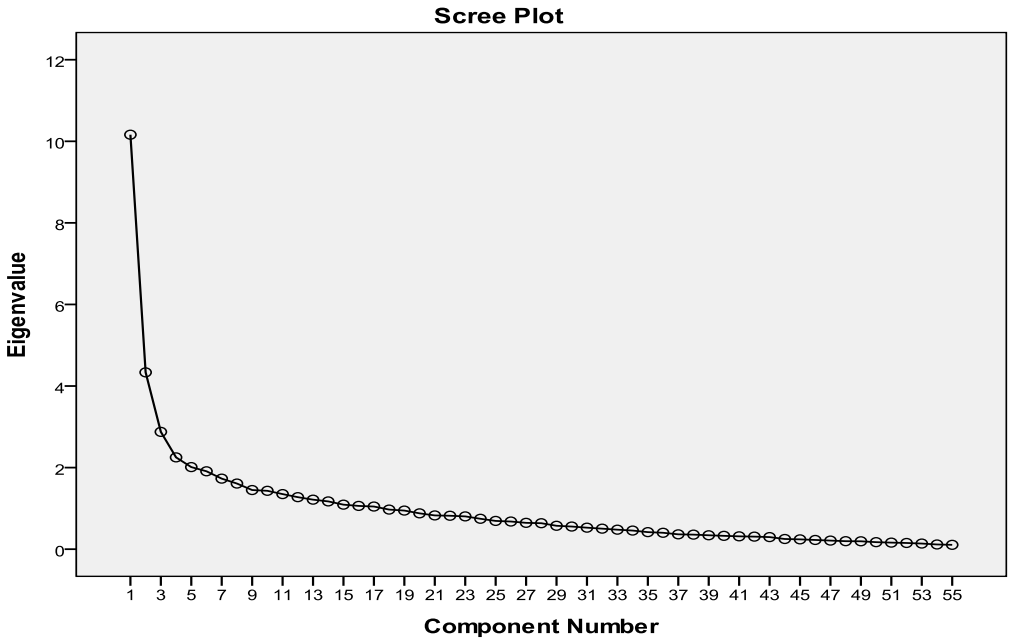
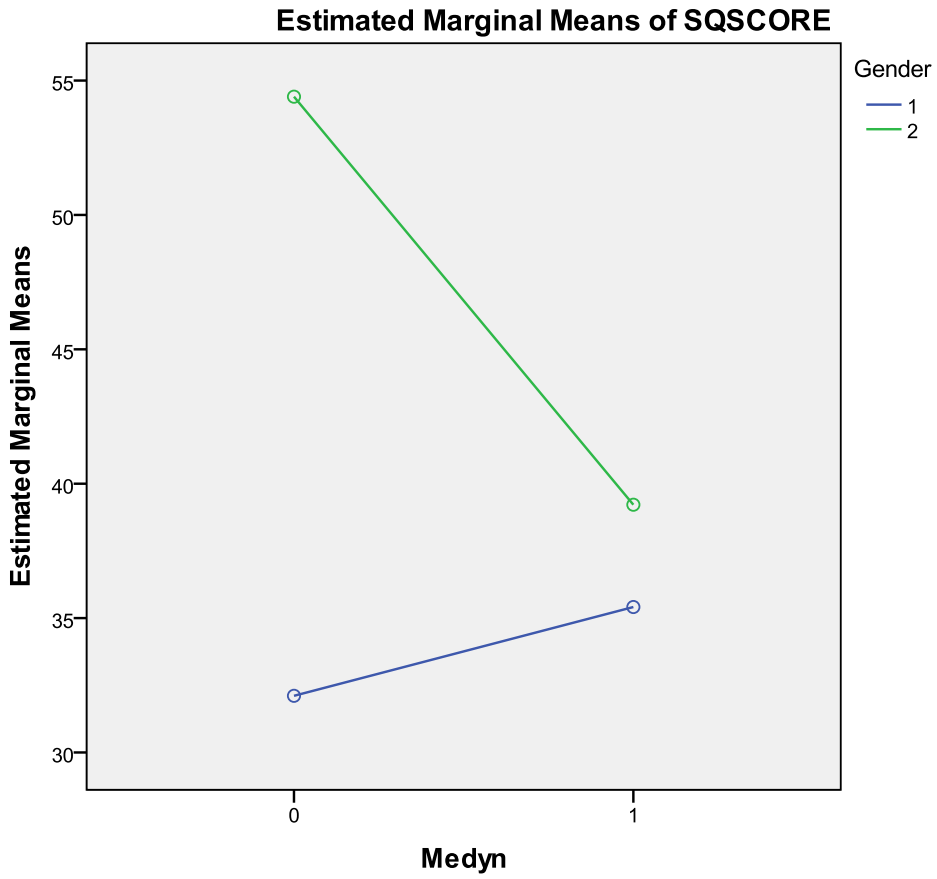


Figure 4

Scree Plot for Factor Analysis, Hypothesis 2



Note: Medyn 0 = ASC Condition
Medyn 1 = Typically Developing
Gender 1 = Male
Gender 2 = Female

Figure 5

ANOVA Interaction

APPENDICES

Appendix A: SQ-Adolescent

Please complete by checking the appropriate box for each statement.

		strongly agree	slightly agree	Slightly disagree	Strongly disagree
1.	My adolescent finds it very easy to use bus schedules, even if this involves several connections.				
2.	My adolescent likes music or book shops because they are clearly organized.				
3.	My adolescent would not enjoy organizing events (e.g., parties).				
4.	When my adolescent reads something, s/he always notices whether it is grammatically correct.				
5.	My adolescent categorizes people into types (in his/her own mind).				
6.	My adolescent finds it difficult to read and understand maps.				
7.	When my adolescent looks at a bridge s/he does not think about how precisely it was made.				
8.	My adolescent finds it difficult to learn how to program video recorders.				
9.	When my adolsecent likes something, s/he likes to collect a lot of different examples of that type of object, so s/he can see how they differ from each other.				
10.	When my adolescent learns a language, s/he becomes intrigued by its grammatical rules.				
11.	My adolescent is not interested in the details of the weather forecast each day (e.g.. pressure, temperature, wind speed, etc.).				
12.	If my adolescent had a collection (e.g., CDs, coins, stamps), it would be highly organized.				
13.	When my adolescent looks at a building, s/he is not curious about the precise way it was constructed.				
14.	My adolescent is not interested in understanding how wireless communication works (e.g., mobile phones).				
15.	My adolescent enjoys looking through catalogues of products to see the details of each product and how it compares to others.				
16.	My adolescent knows, with reasonable accuracy, how much money s/he has spent and how much s/he has got left of his/her pocket money or allowance.				
17.	When my adolescent was younger s/he did not enjoy collecting sets of things (e.g., stickers, football cards etc.).				
18.	My adolescent is interested in the family tree and in understanding how everyone is related to each other in the family.				

		strongly agree	slightly agree	Slightly disagree	Strongly disagree
19.	When my adolescent learns about historical events, s/he does not focus on exact dates.				
20.	My adolescent does not enjoy games that involve a high degree of strategy (e.g., chess, checkers, Risk, Monopoly, etc.).				
21.	When my adolescent learns about a new category s/he likes to go into detail to understand the small differences between different members of that category.				
22.	My adolescent does not find it distressing if people who live with him/her upset his/her routines.				
23.	When my adolescent looks at an animal, s/he likes to know the precise species it belongs to.				
24.	My adolescent can remember large amounts of information about a topic that interests him/her (e.g., flags of the world, airline logos).				
25.	At school, my adolescent does not carefully file all his/her work.				
26.	My adolescent is fascinated by how machines work.				
27.	When my adolescent looks at a piece of furniture, s/he does not notice the details of how it was constructed.				
28.	My adolescent does not try to work out the rules for what to say and do in different social situations.				
29.	My adolescent does not tend to watch science documentaries on television or read articles about science and nature.				
30.	My adolescent would be able to give directions to most parts of town.				
31.	When my adolescent looks at a painting, s/he does not usually think about the technique involved in making it.				
32.	My adolescent prefers social interactions that are structured around a clear activity (e.g., a hobby).				
33.	My adolescent is interested in knowing the path a river takes from its source to the sea.				
34.	My adolescent is a collector (e.g., of books, coins, etc).				
35.	My adolescent's clothes are not carefully organized into different types in his/her wardrobe.				
36.	My adolescent rarely reads articles or web pages about new technology.				
37.	My adolescent does not particularly enjoy learning about facts and figures in history.				
38.	My adolescent does not tend to remember people's birthdays (in terms of which day and month this falls).				
39.	When my adolescent is walking in the country, s/he is curious about how the various kinds of trees differ.				
40.	If my adolescent was getting a camera, s/he would not look carefully into the quality of the lens.				
41.	If my adolescent was getting a computer, s/he would want to know exact details about its hard drive capacity and processor speed.				
42.	My adolescent does not follow any particular system when tidying his/her room.				
43.	If my adolescent was getting a stereo, s/he would want to know about its precise technical features.				

44.	My adolescent tends to keep things that other people might throw away, in case they might be useful for something in the future.				
45.	My adolescent avoids situations which s/he can not control.				
46.	My adolescent does not care to know the names of the plants s/he sees.				
47.	When my adolescent hears the weather forecast, s/he is not very interested in the meteorological patterns.				
48.	It does not bother my adolescent if things in the house are not in their proper place.				
49.	In math, my adolescent is intrigued by the rules and patterns governing numbers.				
50.	My adolescent finds it difficult to learn his/her way around a new city.				
51.	My adolescent could list his/her favorite 10 books, recalling titles and authors' names from memory.				
52.	My adolescent prefers to read fiction than non-fiction.				
53.	When my adolescent has a lot of shopping to do, s/he likes to plan which shops s/he is going to visit and in what order.				
54.	When my adolescent listens to a piece of music, s/he always notice the way it's structured.				
55.	My adolescent could generate a list of his/her favorite 10 songs from memory, including the title and the artist's name who performed each song.				

Appendix B: EQ-Adolescent

Please complete by checking the appropriate box for each statement.

		Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree	Sub-scale
1.	My adolescent can easily tell if someone else wants to enter a conversation.					ToM
2.	My adolescent finds it difficult to explain to others things that s/he understands easily, when they don't understand it the first time.					C
3.	My adolescent really enjoys caring for other people.					SS
4.	My adolescent finds it hard to know what to do in a social situation.					SS
5.	My adolescent often goes too far in driving his/her point home in a discussion.					C
6.	It doesn't bother my adolescent too much if s/he is late meeting a friend.					SS
7.	Friendships and relationships are just too difficult, so my adolescent tends not to bother with them.					SS
8.	My adolescent often finds it difficult to judge if something is rude or polite.					ToM
9.	In a conversation, my adolescent tends to focus on his/her own thoughts rather than on what his/her listener might be thinking.					ToM
10.	When s/he was younger, my adolescent enjoyed cutting up worms to see what would happen.					SS
11.	My adolescent can pick up quickly if someone says one thing but means another.					ToM
12.	It is hard for my adolescent to see why some things upset people so much.					ToM
13.	My adolescent finds it easy to put him/herself in somebody else's shoes.					ToM
14.	My adolescent is good at predicting how someone will feel.					ToM
15.	My adolescent is quick to spot when someone in a group is feeling awkward or uncomfortable.					ToM
16.	If my adolescent says something that someone else is offended by, s/he thinks that that's their problem, not his/hers.					ToM
17.	If anyone asked my adolescent if s/he liked their haircut, s/he would reply truthfully, even if s/he didn't like it.					C
18.	My adolescent can't always see why someone should have felt offended by a remark.					ToM
19.	Seeing people cry doesn't really upset my adolescent.					ToM
20.	My adolescent is very blunt, which some people take to be rudeness, even though this is unintentional.					C
21.	My adolescent doesn't tend to find social					SS

	situations confusing.					
22.	My adolescent is good at understanding how people are feeling and what they are thinking.					ToM
23.	When my adolescent talks to other people, s/he tends to talk about the other person's experience rather than his/her own.					C
24.	It upsets my adolescent to see an animal in pain.					ToM
25.	My adolescent is able to make decisions without being influenced by people's feelings.					SS
26.	My adolescent can easily tell if someone else is interested or bored with what s/he is saying.					ToM
27.	My adolescent gets upset if s/he sees people suffering on news programmes.					ToM
28.	His/her friends usually talk to my adolescent about their problems as they say that s/he is very understanding.					C
29.	My adolescent can sense if s/he is intruding, even if the other person doesn't tell him/her.					ToM
30.	My adolescent sometimes goes too far with teasing.					C
31.	My adolescent is often insensitive, though s/he doesn't always see why.					C
32.	If my adolescent saw a stranger in a group, s/he would think that it is up to them to make an effort to join in.					ToM
33.	My adolescent usually stays emotionally detached when watching a film.					ToM
34.	My adolescent can tune into how someone else feels rapidly and intuitively.					ToM
35.	My adolescent can easily work out what another person might want to talk about.					ToM
36.	My adolescent can tell if someone is masking their true emotion.					ToM
37.	My adolescent doesn't consciously work out the rules of social situations.					SS
38.	My adolescent is good at predicting what someone will do.					ToM
39.	My adolescent tends to get emotionally involved with a friend's problems.					ToM
40.	My adolescent can usually appreciate the other person's viewpoint, even if s/he doesn't agree with it.					ToM

EQ-A Subscale Code (if dividing subscales into applied components)
ToM – Theory of Mind (cognitively understanding the feelings of others)
C – Communication (mainly verbal communication)
S – Social Skills (social situations)

Appendix C: Recruitment Fliers

Win a **$25 APPLEBEES GIFT CERTIFICATE**

by completing an

AUTISM SPECTRUM CONDITION SURVEY

Mothers of children with autism spectrum conditions aged 12-16 are eligible

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