RELATIONSHIPS BETWEEN SUB-CLINICAL AUTISTIC TRAITS, COGNITIVE SUBSTRATES, AND SOCIAL FUNCTIONING IN A TYPICALLY DEVELOPING COLLEGE SAMPLE

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ABSTRACT

Timothy D. Perry: Relationships between sub-clinical autistic traits, cognitive substrates, and social functioning in a typically developing college sample
(Under the direction of David L. Penn, Ph.D)

The continuum theory of autism argues that the behavioral traits associated with the disorder are normally distributed throughout the population. Studies suggest that these traits can be reliably measured in first-degree relatives of individuals with autism and, more recently, in individuals in the general population. What remains unclear, however, is whether these traits in the general population are associated with similar cognitive and social profiles as those observed in autism. The current study examined associations between autistic traits, cognitive substrates, and social functioning in a group of typically developing college students. Sixty-seven undergraduate participants were recruited to complete self-report measures of autistic traits and social functioning and performance-based measures of theory of mind, executive functioning, and weak central coherence. Data was used to evaluate a model of relationships among these variables in a path analytic model. Results from this study partially supported the continuum hypothesis. Theory of mind was found to be strongly related to social autistic traits and social functioning while executive functioning was associated with non-social autistic traits. Results were also consistent with previous reports of higher endorsement of autistic traits among male participants than female participants and among individuals majoring the physical sciences as opposed to those majoring in the arts and humanities. Implications for the findings with regard to the manner in which autism is conceptualized, studied, and treated are discussed.

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CHAPTER 1: INTRODUCTION

A General Overview

The primary aim of this dissertation is to investigate relationships among subclinical autistic traits, cognitive substrates related to autism, and social outcomes in a group of typically developing young adults. Autism Spectrum Disorders (ASDs) are increasingly conceptualized as part of a spectrum of severity with the disorder on one end and normal functioning on the other (Constantino & Todd, 2003; Posserud, 2006). Additionally, sub-clinical autistic traits have been ascribed to individuals who do not meet diagnostic criteria for the disorder in relatives of individuals with autism (Bolton et al., 1994; Piven et al., 1997) and, more recently, among individuals in the general population (Austin, 2005; Hoekstra, Bartels, Verweij, & Boomsa, 2007; Hurst et al., 2007).

Important questions remain, however, in order to further validate the continuum theory with reference to non-affected individuals. For instance, it is unclear whether the three symptom domains are related to one another in a manner similar to that observed in autism. Autism is diagnosed based on the co-occurrence of social and communication deficits and repetitive behaviors/restricted interests (RRBIs) (APA, 2000). This criterion has led to the assumption that these symptom domains are closely related and associated with a common cause. Recent research, however, has suggested that although the social

and communication domains are closely related in individuals with autism, the RRBI domain is fairly independent of these domains (Mandy & Skuse, 2008). Similar findings in typically developing samples would support the idea of the autism continuum.

Another important unanswered question involves the extent to which autistic traits in non-autistic individuals are associated with the same underlying cognitive substrates and social deficits as those seen in autism. Theory of mind (ToM), executive dysfunction (EF), and weak central coherence (WCC) have each been proposed as cognitive substrates which underlie autistic symptoms (Rajendran & Mitchell, 2007). Studies examining these factors in typically developing samples have produced conflicting results (Best, Moffat, Power, Owens, Johnstone, 2008; Kunihira, Senju, Dairoku, Wakabayashi, & Hasegawa, 2006). This inconsistency may be due, in part, to sample characteristics (disability status) and measurement issues (insufficient sensitivity). Similarly, impairments of social functioning are a hallmark feature of ASDs at both high and low functioning levels. But these impairments have not been consistently found among non-autistic individuals with autistic traits. The continuum theory of autism would predict that these deficits will also be apparent, in milder forms, in typically developing individuals with autistic traits. Further, it would predict that the relationship between the cognitive substrates and social functioning will be partially mediated by autistic symptoms. Findings suggesting similar, but attenuated, underlying cognitive substrates and social impairments among those with sub-clinical autistic traits are supportive of the continuum hypothesis of autism. Those suggesting differing patterns support the conceptualization of autism as qualitatively different from typical development.

In the following literature review, I will first discuss autism as a diagnostic category and the continuum theory of autism. Next, I will examine the symptom domains of autism and evidence of autistic traits among typically developing individuals. Following this discussion, I will outline the three dominant cognitive theories of autism (ToM, EF, and WCC) and discuss their relationship to autistic symptoms and social functioning. This dissertation aims to extend previous research by employing a path analytic model to investigate the pattern of relationships between autistic symptom domains, cognitive substrates, and social functioning in a college sample, examining autistic symptom domains, and by using multiple measures with sufficient sensitivity to detect subtle individual differences.

Background and Significance

Autism is a neuro-developmental disorder characterized by impairment in the domains of social interaction and communication as well as restricted interests and repetitive behaviors (APA, 2000). These impairments were first noted by Kanner (1943) when he described children with pronounced difficulties in social interaction and problems with emotional expression and recognition. Since that time, numerous studies have sought to characterize autistic traits and their relationships to social outcomes. These traits have been linked to difficulties in independent living (Tantam, 1991), psychiatric dysfunction (Green, Gilchrist, Burton, & Cox, 2000), social isolation, and peer rejection (Orsmond, Krauss, & Seltzer, 2004).

Since Kanner's initial description, recognition of the diverse clinical presentations of autism has increased. During the same period, Asperger (1945) observed children who shared many characteristics with those described by Kanner (poor peer

relations, narrow interests, irregular eye gaze). These children also differed in important ways from those in Kanner's group. The children Asperger described had average to above average cognitive abilities and were less impaired in terms of adaptive and social functioning than those described by Kanner. Also, notably, Asperger described the children he observed as "little professors" due to their pedantic style and precocious use of speech. This characterization is in stark contrast to Kanner's observations of language deficits (Mesibov, Shea, & Adams, 2001). Asperger's writings were not translated into English, however, until 1991 by Frith. With their publication and other work by Wing (1986) explicating the disorder, came increased interest in the concept of the autistic spectrum. Asperger's Disorder was subsequently added to the Diagnostic and Statistical Manual, Fourth Edition (DSM-IV) in 1994 alongside the previously identified Autistic Disorder (APA, 2000). Though these conditions appear dissimilar in many ways, they are understood as part of a spectrum of autistic disturbance ranging from near normal functioning to severe impairment. Upcoming changes to diagnostic criteria with the introduction of the DSM-V appear to reflect recognition of the broad spectrum of severity of autistic symptoms. These changes include removal of Asperger's disorder as a separate diagnosis in favor of the umbrella diagnosis of Autism Spectrum Disorder along with ratings of impairment severity (APA, 2013). This shift from categorical conceptualization to dimensional understanding is consistent with the continuum theory of autism.

Increasing evidence supports further broadening of this spectrum model to include both clinical and subclinical manifestations of autistic symptoms (Skuse, Mundy, & Scourfield, 2005). The Broader Autism Phenotype (BAP), for example, describes

personality characteristics and subclinical symptoms often found in first degree relatives of individuals with ASD which represent a genetic liability for the disorder (Piven, Palmer, Jacobi, Childress, & Arndt, 1997). The original work on the BAP found that up to 20% of siblings of individuals with autism exhibited a deficit in one or more core areas associated with ASD (social interaction, communication, and restricted and repetitive behaviors) (Bolton et al. 1994). Subsequent studies of family members have suggested that the BAP is associated with specific personality features, such as rigidity, aloofness, and anxiety (Murphy et al. 2000), interpersonal difficulties, such as deficits in the number and quality of friendships (Grinter, et al., 2001), pragmatic language deficits (Landa et al. 1992), and cognitive deficits, such as impaired executive functioning (Hughes, Leboyer, & Bouvard, 1997; Ozonoff , Rogers, Farnham, & Pennington, 1993) and systemizing strength (Grinter, et al., 2001).

Recent studies have proposed that the BAP is not restricted to family members of individuals with autism, and that autistic behavioral traits are normally distributed in the general population (Hoekstra et al., 2007; Hurst et al., 2007). Constantino and Todd (2003) administered the Social Responsiveness Scale (SRS) to the parents of 788 typically developing pairs of twins between the ages of 7 and 15. This study concluded that autistic traits were continuously distributed in this group. Levels of severity ranged from zero traits to levels comparable to clinical cutoffs. Similarly, Posserud (2006) administered teacher and parent report forms of the Autism Spectrum Screening Questionnaire (ASSQ) in a population study of 7 to 9 year-old children. They found that these scores were “almost continuous” and classified 2.7% of the children as high-scorers.

Evidence of autistic traits in the general population has also come from studies using self-report measures. Austin (2005) examined personality correlates among a group of undergraduate college students using the Big Five Personality Inventory and the Autism Spectrum Quotient (AQ) (Baron-Cohen et al., 2001). This study found that people who endorsed a high level of autistic traits also scored highly on Neuroticism and Introversion, and tended to receive low scores on the Agreeableness scale. Austin (2005) suggests that these personality traits map on to the autistic characteristics of anxiety, rigidity, and social withdrawal. Ingersoll (2010) administered the AQ to 106 undergraduate students and found an association between autistic traits and the ability to interpret non-verbal behavior as measured by the Diagnostic Analysis of Nonverbal Accuracy (DANVA2) and the Test of Nonverbal Cue Knowledge (TONCK). This study found AQ scores ranging from 7-30 (out of 50) which is consistent with previous studies in college populations (Baron-Cohen, et al. 2001).

The recent focus on autistic traits in the general population has produced intriguing findings regarding the nature of autistic impairment, but has not done so without controversy. The concept of the BAP in relatives of individuals with autism proceeds from the assumption that these individuals share autistic traits with relatives due to a common genetic origin and has stimulated research into the genetic causes of autism. Many studies of the BAP also categorize individuals into groups "with" and "without" the BAP based on cut-off scores on measures of autistic traits. This characterization is at odds with the continuum theory and, rather, implies that autism is a condition qualitatively distinct from normal development. Several assumptions of the continuum theory do indeed need to be validated, but studying autistic traits in typically developing

individuals provides an opportunity to gain insight into the nature of the disorder as well as normal development.

The Autistic Triad of Deficits

Although autism is considered to be one of the most heritable of the psychological disorders, the lack of a viable single gene explanation suggests that separate genes may be responsible for different autistic symptoms (Happe & Ronald, 2007). These social, communication, and behavioral symptoms may, in turn, have different neural and cognitive causes. Researchers have studied the extent of interrelation among these domains in samples with and without autism.

The idea that autistic symptom domains may have unique and independent determinants has existed in autism research for some time. Wing (1971) discussed the difficulty of attributing these disparate symptoms to a single abnormality. Rather, she advocated explaining autism as the result of multiple impairments and suggested some individuals might only meet criteria for the disorder in one symptom domain. Similarly, Goodman (1989) and Bishop (1989) reported observations that children without an autism diagnosis frequently showed one or more symptom of autism. These examples notwithstanding, the predominant view has supported the idea that one of the most important goals of autism research is the search for genes responsible for susceptibility in all three domains.

A number of factor analytic studies have attempted to characterize the dimensional structure of ASD symptoms using samples with autism. Although the majority of studies have found strong relationships between social and communication domains, many do not find associations between these domains and RRBI's (Happe and

Ronald, 2007). Many studies have combined the social and communication domains to form one "social factor" and termed the behavioral domain a "non-social factor." Mundy and Skuse (2008) reviewed seven studies and found that all but one observed evidence for multiple factors underlying autistic behaviors, and all produced a social impairment factor and a nonsocial factor. Tanguay, Robertson, and Derrick (1998) examined the triad in a group of children with Pervasive Developmental Disorder, Not Otherwise Specified (PDD-NOS) and found that nearly all displayed social and communication impairments, but few demonstrated non-social symptoms (RRBIs). Silverman et al. (2002) also found that RRBIs do not cluster with social and communication impairments and this finding has been replicated by a number of other studies using both informant rated and self-report measures (Austin, 2005; Constantino et al., 2004; Georgiades et al., 2007; Lecavalier, 2005; Miranda-Linne & Melin, 2002 Tadevosyan-Leyfer et al., 2003; van Lang et al., 2006).

Although using samples comprised of individuals with autism to investigate these domains is beneficial in some regards, it also has disadvantages. An advantage of using clinical ASD samples to study the structure of autistic symptom domains is that their face validity is not questioned. In contrast, when studying general population samples, even with a reliable and valid measure of autistic behaviors, one question often raised is how the data actually relate to clinical ASD. Nevertheless, the restricted variance in narrowly defined clinical samples, and the circularity of investigating the relationship between the triad of impairments in a sample of individuals who, by definition, show all three difficulties, suggests that non-clinical samples should be employed to study the autistic triad (Happe & Ronald, 2007; Myrh, 1998).

One of the earliest and most influential studies suggesting the independence or "fractionability" of the autism symptom domains with a non-autistic sample was conducted by Wing and Gould (1979). This study, with a sample collected from a psychiatric and mental retardation registry, investigated the prevalence of the triad of impairments and the extent to which they co-occur. Participants were a clinical sample of children chosen from an epidemiological study. Of 914 children, 132 were selected because they showed impairment in at least one domain or were severely intellectually impaired. The authors assessed the children using observations and interviews with teachers, care staff, and parents and categorized children based on the presence or absence of specific social, communication, and RRBI features. Comparisons were made between those with and without any type of social impairment, and between those with and without a social abnormality meeting autism criteria. The authors reported evidence of a tendency for these problems to occur together. For example, of 74 children with any social impairment, 55% also had no symbolic activities, 55% had no speech, and 72% had only repetitive interest patterns; the results indicated a clustering of the triad. By comparison, the percentages for the sociable children with intellectual disability were 10%, 33%, and 7%, respectively.

Comparisons across groups formed on the basis of type of social impairment found social aloofness was most commonly associated with language impairments and RRBIs; 89% of the socially aloof had no speech and all (N=37) had no symbolic play and only repetitive interest patterns. Some children with passive interaction and active but odd interaction also showed language problems and RRBIs, but the overlap was not significant. They found 50% of the socially passive children and 65% of the socially odd

children were not limited to repetitive interest patterns, and had constructive and repetitive interest patterns, and most (82–85%) did not show elaborate repetitive routines, that is, they had social impairments but fewer RRBIs. Also, 29–50% of the socially passive and socially odd children had no echolalia and a majority (65– 94%) had speech, (i.e., social impairments but fewer language problems). Four children showed repetitive interest patterns and had severe intellectual disability, but had appropriate social interaction (i.e., RRBIs but no social impairments). In short, some children showed social impairments (passive or odd interaction) but not RRBIs, and vice-versa. This study's goal was to investigate the extent to which the behaviors described by Kanner clustered together in a clinical, but non-autistic sample, using a systematic approach. There was evidence for substantial clustering of social impairments, communication impairments, and RRBIs, particularly when social aloofness was the social impairment. However, the study also clearly documented that some children had only certain aspects of the autism phenotype, and not others.

Another important consideration related to the findings from this study involves the broadening understanding of autism. Interpretation of these findings nearly 30 years after this study is limited by changes in definition and criteria for ASDs. The working definition for autism at the time of this study was quite narrow by current standards, and Wing has since suggested that there are no clear divisions between Kanner's autism and the other subgroups, and that these should all be considered within the concept of the triad of impairments (Wing, 1981). The study was also limited by relatively small numbers of children, especially when divided into subgroups. In addition, and perhaps most critically, the sample was selected from a psychiatric and mental retardation register

(Caron & Rutter, 1991). It is possible that some of the participants would, today, be diagnosed with High-Functioning Autism, PDD-NOS, or Asperger's Disorder as those classifications were used less frequently or nonexistent at the time of the study. Furthermore, almost one fourth of the 900 children originally screened had at least one of the problems assessed by the interview schedule (Wing et al., 1976). In most cases, the authors decided that the problem was atypical for autism and the child was excluded. Although some of these children would now be diagnosed with an ASD, at that time impairments had to be more severe to reach the diagnostic threshold. These limitations suggest that it would be useful to explore this research question again with heterogeneous ASD and non-ASD samples.

Recent studies have also investigated the fractionability of the autistic triad in typically developing community samples. Ronald and colleagues published two reports (Ronald et al., 2006, 2005) suggesting only a minimal to moderate association between autistic social-communication impairments and nonsocial behaviors. In these studies, they gave a questionnaire to parents and teachers of over 3,000 twins, who were part of a study of twin development. The questionnaire had 10 items designed to measure social impairments and six items addressing nonsocial behaviors relevant to autism. The study found correlations between social and non-social factors of .29 in the parent data and .15 in the teacher data. These modest correlations also applied to participants at the extreme high end of the distribution. Thus, according to teacher report, of those scoring in the top 5% of social traits, only 14% also scored in the top 5% for non-social traits. Parent report results showed a similar pattern: of those children scoring in the top 5% for either social or non-social traits, only 15% scored in the top 5% of both scales. Although these studies

provide compelling evidence of the independence of social and non-social autistic traits, they have been criticized on the basis of the poor psychometric properties of the measures (LeCavalier, et al, 2009; Mandy & Skuse, 2008). More research is needed with community samples employing more established and psychometrically sound measures of autistic traits.

The studies outlined above point to the need to continue investigating the clustering of autism symptom domains. Additionally, homogenous non-clinical samples may provide useful insight in the nature of autism as well as typical development. A commonly cited shortcoming of treatments developed for individuals with autism is that they fail to address the varied needs of individuals with ASD diagnoses (Bauminger, 2002). Gaining a better understanding of autistic subtypes based on symptom domains, may allow for more targeted and effective treatments. Also, these treatments may also benefit individuals without an ASD diagnosis who have impairments in one of the symptom domains. To design these treatments, though, will also require an improved understanding of what underlies these difficulties. Thus, determining the cognitive substrates related to social and communication impairment and RRBI's is also a worthy research goal.

Cognitive Theories of Autism

Since autism was first described, many theories have been proposed to account for this enigmatic condition. One famous example is Bettelheim's "refrigerator mother" theory (1967) which suggested that withholding of parental affection caused autistic symptoms. This theory has since been discredited in favor of more cognitively focused theories. Three cognitive theories have dominated autism research for the last thirty

years: The theory of mind hypothesis, the theory of executive dysfunction, and the theory of weak central coherence. These theories and research findings with samples with autism and first-degree relatives of individuals with autism are described below. Limitations of the theories with regard to explaining social and non-social autistic symptoms are also discussed. Following this discussion, research findings with non-clinical samples is presented.

Theory of Mind

ToM has been defined as the ability to attribute mental states (thoughts, feelings, beliefs, etc.) to oneself and others (Premack & Woodruff, 1978). It also involves an understanding that the mental states of others can be different from one's own and the ability to use this understanding to predict behavior (Leslie, 1991). Research investigating the relationship between ToM and autism was initiated by Baron-Cohen, Leslie, and Frith (1985) in an attempt to unite disparate explanations of individual autistic symptoms. Prior to this theory, a number of the behavioral features observed among individuals with autism were attributed to concomitant intellectual disability. Baron-Cohen and colleagues, however, argued that autism involved specific social impairments which could not be solely attributable to cognitive impairment. To support this position, they also pointed out research indicating that children with autism and average or above average cognitive skills experience social impairments, and children with intellectual disability without autism (i.e. Down's syndrome) were more socially competent than their peers with autism. In order to understand the core deficits of autism, the researchers argued, underlying cognitive mechanisms must be considered independent of cognitive

functioning. They proposed ToM as such a cognitive mechanism due to the demonstrated relationship between ToM in children and imaginative play.

The capacity for imaginative or pretend play depends, in part, on the ability to form second order meta-representations. Research suggests that this ability begins to develop for typically developing children in the second year of life. This time period corresponds with the development of interest in imaginative play and also corresponds with early reports of atypical behavior in cases of autism (Begeer, Rieffe, Terwogt, & Stockman, 2003). To provide support for a ToM hypothesis of autism, Baron-Cohen and colleagues administered a false belief task assessing ToM skills to children divided into three groups. The first group was composed of 20 children with autism and average to above IQ scores. The second group was composed of 14 children with Down's Syndrome with intellectual disability. The third group consisted of 27 typically developing children. Twelve of the 14 (85 %) children with Down's syndrome responded to the task correctly and 23 out of 27 (80%) of the typically developing children answered correctly. In contrast, only 4 of the 20 children with autism (20%) responded to the task correctly. The authors interpreted this finding as a clear evidence of deficient mind reading skills in autism and argued that this failure explained the core deficits related to autism spectrum disorders. This study's findings have been replicated by numerous researchers using false belief tasks (Bauminger & Kasari, 1999; Burnette, Mundy, Meyer, Colle, Baron-Cohen, & Hill, 2007; Hillier & Gomez, Swettenham Toye, & Lagattuta, 2002; Allinson, Kerr & Durkin, 2004; 2002; Norbury, 2005; Pelicano, 2007; Peterson & Siegal; Slaughter, Peterson, & Mackintosh, 2007; Wellman, Baron-Cohen, Cashwell). Swettenham and colleagues (1996) used false belief tasks to teach children

with autism strategies to correctly respond to the prompts given in these tasks. They observed that the children were able to learn the strategies, but were unable to employ them to predict mental states of characters in the stories. Aside from the lack of generalization often seen in studies with individuals with autism, this study demonstrates the automatic nature of ToM reasoning and the extent to which this automaticity is impaired in autism. Results also suggest that this ability is difficult to teach, in part, because of its fundamental nature.

Another study used several false belief tasks to compare children with pervasive development disorder-not otherwise specified (PDD-NOS) to typically developing children. Based on the results of this study, the authors concluded that ToM development in children with milder symptoms of autism was both delayed and abnormal in character (Serra et al., 2002). Similarly, studies have generally indicated impairment in ToM ability using indirect communication and implied meaning tasks with individuals with autism (Brent, Rios, Happe, and Charman, 2008). Kaland, Callesen, Moller-Nielsen, Mortensen, and Smith (2008) compared performance on the Strange Stories task in a group of children and adolescents with Asperger's disorder and high-functioning autism (HFA) and a group of typically developing age matched peers. They found that the children with autism gave significantly more incorrect responses than their peers.

Evidence also suggests that first-degree relatives of individuals with autism perform more poorly than non-affected individuals on ToM tasks. Baron-Cohen and Hammer (1997) administered the Reading the Mind in the Eyes Task to parents of children with autism. This measure includes pictures of the eye area of faces and asks participants to decide which expression is being displayed from a list of choices. The

study found that the parents of children with autism were less accurate than age and IQ matched control participants. Similarly, Losh and colleagues (2009) reported ToM impairment among first-degree relatives of individuals with autism using the Eyes Task and other emotion decoding measures. Gocken, Bora, Eremis, Kesiki, and Aydin (2007) also found that parents of individuals with autism performed more poorly than controls on ToM tasks involving indirect speech. They administered the Hinting Task (Corcoran et al., 1995) to 76 parents of children with autism and 41 parents with typically developing children. This task consists of stories in which one character hints about his or her intention rather than explicitly stating it. Participants are asked to identify the character's intention based on the hint. Gocken et al. (2007) found that parents of children with autism were less accurate at guessing the intention than control parents. These studies point to the potential usefulness of ToM as a genetic marker for autism. They also indicate that the boundaries of the autism phenotype extend beyond clinical diagnosis.

Although there is general agreement concerning impairment of ToM skills related to autism, some studies have questioned the universality of this impairment in autism and the utility of this impairment as a unified cognitive theory of autistic symptoms. Several studies with individuals with HFA show that they are as capable as controls of correctly attributing mental states on simple, first order false belief tests (Happe, 1993; Ozonoff et al., 1991). However, these individuals reliably fail more complex ToM tasks. This finding seems to suggest that false belief tests may not be inappropriate for those without cognitive impairment. Significantly, other studies have shown that even when higher-functioning individuals with autism are able to pass ToM tasks, they are often unable to

employ these skills in real life social situations (e.g. Klin, Jones, Schultz, and Volkmar, 2003).

Another criticism of the ToM explanation of autism is that it does not explain some of the key features of the disorder. ToM impairment does not, for example account for the hallmark feature of autism of RRBIs (Happe, 2001: Tager-Flusberg, 2007). Researchers once suggested that RRBIs served to reduce anxiety which resulted from a lack of social understanding characterized by poor ToM abilities; but this theory appears insufficient to explain the variation among autistic the symptom profiles (Happe & Ronald, 2007). Nor does such a deficit explain the particular strengths related to autism such as superior visual-attention skills or enhanced memory abilities (Tager-Flusberg, 2001). Consequently, future research should focus more closely on sub-groups of individuals with autism (i.e. general autism, HFA, Asperger's Disorder) as well as groups without autism who have autistic traits, and the unique challenges and strengths associated with these groups.

Though the relationship between ToM ability and social functioning in autism appeared relatively straightforward in early research, it has recently been challenged. Fombonne, Siddons, Archard, Frith, and Happe (1994) administered the social functioning sections of the Vineland Adaptive Behavior Scales to parents of 19 adolescents and adults with autism. False belief tasks were also administered to the adolescents and adults with autism. Results showed that individuals who passed false belief tests were rated as more socially competent by their parents than those who did not pass. Although this finding has been replicated by a number of other researchers (e.g., Frith, Happé & Siddons, 1994; Hughes, Soares-Boucaud, Hochmann & Frith, 1997;

Tager-Flusberg, 2000), other studies have questioned the connection between ToM and social functioning. A number of studies suggest that individuals with autism who pass false belief tasks are unable to apply this understanding in real world settings (e.g., Bauminger & Kasari, 1999; Dahlen & Trillingsgaard, 1996; Howlin, 1998). Ozonoff and Miller (1995) examined the effectiveness of a social skills training group for high-functioning adolescents with autism. At post-test, they found improvements in performance on false belief tasks, but did not find improvements in parent ratings of social functioning. This result was interpreted as possible evidence that social functioning is not related to ToM ability. Another potential interpretation, however, is that false belief tasks are not appropriate measures for high-functioning individuals. These individuals likely compensate for poor emotional understanding with intellectual ability in controlled settings, but having trouble doing so in naturalistic social interactions (Bauminger, 2002). It also suggests that these measures are inappropriate for use in BAP studies with family members or in general population samples. Consequently, additional research should be conducted using ToM tasks which mimic real world social encounters more closely than false belief tasks. Advanced ToM tasks which include indirect language and gestures may allow for the detection of the subtle difference that exist in a typically developing sample.

Executive Dysfunction

Many of the autistic traits, which cannot be explained by deficits in ToM, can reasonably be explained by impairments in executive functioning. In contrast to the theory of mind hypothesis of autism, the Executive Function (EF) account was not based on neuro-typical research; rather, it came from researchers who noted that some

symptoms of autism were similar to those associated with specific brain injury. For example, a need for sameness, a difficulty switching attention, a tendency to perseverate and a lack of impulse control are symptoms similar to those shown by individuals with what is now known as Dysexecutive Syndrome (Baddeley & Wilson, 1988). Such individuals have problems with executive function usually, but not exclusively, due to frontal lobe damage. This led some researchers (e.g., Ozonoff et al., 1991) to suggest that autism could be explained as deficit in EF.

Historically, the notion of EF comes from the analysis of the resultant damage to the Prefrontal Cortex (PFC). Recently, however, EF studies have been carried out by researchers of typical and atypical cognitive development (Zelazo & Müller, 2002). Despite EF being traditionally related to the PFC, EF is not the same as PFC function. For example, Shallice and Burgess (1991) found that some individuals with PFC damage did not show impairments in EF, while some people with damage outside the PFC do show impairments (e.g., Anderson, Damasio, Jones, & Tranel, 1991; Levisohn, Cronin-Golomb, & Schmahmann, 2000). Interestingly, the PFC is also thought by some to be a site of theory of mind abilities (Shallice, 2001; Stone, Baron-Cohen, & Knight, 1998; Stuss, Gallup, & Alexander, 2001) and, thus, may hint at a shared brain site for these functions.

Executive Functioning is an umbrella term for functions including initiating, sustaining attention, attention shifting and inhibition (Denkla, 1996). Ozonoff and colleagues (1991) defined EF as the ability to maintain an appropriate problem-solving set for attainment of a future goal. They stated that it includes behaviors such as planning, impulse control, inhibition of prepotent but irrelevant responses, set

maintenance, organized search, and coordination of thought and action. Tranel, Anderson, and Benton (1994) suggested that EF involves planning, decision-making, judgment and self-perception. In contrast, Gillberg and Coleman (2000) describe EF as all those faculties needed to work in a motivated fashion, towards a goal that may not be reached instantly.

In reviewing the EF autism literature, Hill (2004a, 2004b) divided studies into categories of EF: planning, mental/cognitive flexibility (set shifting), inhibition, generativity and self-monitoring. Hill's review suggests that evidence for a unique deficit in autism in one of these functions seems unlikely. However, it may still be that a distinct EF profile distinguishes autism from other neurodevelopmental disorders. The search for such a profile will be a key aim in the coming years. Differentiating between disorders on the basis of EF is not made any easier because of the difficulty in isolating the specific form of EF impairment; probably because EF tests have been designed to investigate only one aspect of EF while in fact they often measure multiple executive abilities (Burgess, 1998). Hence, a key challenge facing EF research lies is in designing tests and studies that measure one aspect of EF in isolation. For example, the frequently used Wisconsin Card Sort Task is interpreted as examining cognitive flexibility through set shifting; this task has been thought to tap into just one executive process, but in fact it may draw upon several (see Zelazo, Burack, Boseovski, Jacques, & Frye, 2001).

The majority of studies assessing EF in groups of individuals with autism have focused on the functions of planning and cognitive flexibility (Hill, 2004; Liss et al, 2001; Ozonoff and Jensen, 1999; Shu et al, 2001). Hughes (1996) found evidence of a planning deficit for goal-directed motor actions. In this study, Luria's Bar Task was

administered to a group of children with autism and age and IQ matched controls. This task uses a simple grasp and place mechanism which involves planning with regard to which hand the participant uses. This task was completed more quickly by control participants than individuals with autism. Rumsey and Hamburger (1988) also reported evidence of problems with cognitive flexibility after administering the Trail Making Test (TMT) to groups of individuals with and without autism. The group with autism completed this task requiring them to join letters and numbers in a proscribed sequence more slowly than the control group.

Impaired executive functioning has also been associated with the broader autism phenotype in studies of parents (Hughes, Leboyer, & Bouvard, 1997) and siblings (Hughes, Leboyer, & Plumet 1999) of children with autism. In one study, parents showed deficits in cognitive flexibility and fluency, and siblings only had mild reduction in non-fluency and weakness in verbal fluency (Wong, Maybery, Bishop, Maley, &Hallmarker, 2006). Similarly, Nyden, Hagberg, Gousse, and Rastam (2011) administered the Tower of London planning task and the TMT to 18 mothers, 18 fathers, and 50 siblings of individuals with autism and 35 matched controls. This study found evidence of executive dysfunction in planning among family members of individuals with autism relative to the control group but did not see differences in cognitive flexibility between the groups.

Given the evidence of executive dysfunction among individuals with autism and first-degree relatives of individuals with autism, more research needs to be conducted with samples from the general population to assess the boundaries of this cognitive phenotype. Christ, Kane, and Reiersen (2010) administered the Behavior Rating

Inventory of Executive Functioning (BRIEF) to groups of typically developing individuals endorsing high and low autistic traits (groups of 66 and 28, respectively). This study found that autistic traits accounted for a significant proportion of variance in global executive functioning scores.

One obvious criticism of EF as an explanation for autistic symptoms is that it does not adequately address the social symptoms of the disorder, which are often the most debilitating. It may be that problems shifting attention and problems with cognitive flexibility underlie problems in social interactions, but these problems appear to be better accounted for by ToM abnormalities (Happe & Ronald, 2007). Because executive functioning does not appear to explicitly related to social symptoms, it has also been less thoroughly investigated with regard to social functioning than ToM in autism. In other populations, however, poor social functioning does appear to be related to impaired executive functioning (i.e., Hanks, Rapport, Millis, & Deshpande, 1999). Overall, because these two theories have been unable to account for the full autism triad, researchers have searched for a cognitive construct, which might explain both the social and non-social aspects of the disorder.

Weak Central Coherence

The Weak Central Coherence Theory (WCC; Frith, 1989, 2003; Frith & Happe, 1994; Happe, 1999) is a domain general process with the key strength that it explains some of the non-social, as well as the social features of autism, such as the attention to acute detail. The essence of the theory is that typically developing individuals process information by extracting overall meaning. Frith and Happe (1994) argue that autism is characterized by weak or absent drive for this overall meaning or global coherence.

According to this theory, individuals with autism process things in a detail-focused or piecemeal way, processing the constituent parts, rather than the global whole. The WCC theory has reinvigorated research into the perceptual abilities of individuals with autism and has the additional strength of explaining both key weaknesses and key strengths of the disorder.

The initial work on central coherence focused on perceptual processes (Mitchell & Ropar, 2004). Evidence came from studies showing that children with autism scored above average on the Children's Embedded Figures Test (CEFT, Witkin, Oltman, Raskin, & Karp, 1971) and performed better than chronologically and mental age matched typically developing children. In the CEFT, participants are asked to locate a small target shape in a drawing of a larger everyday shape composed of potentially confusing lines. When looking at the figures, it seems as if the larger shapes are so captivating that the smaller embedded shape is hard to detect. Shah and Frith (1993) also found that participants with autism were faster at reproducing 40 different block designs than learning disabled and typically developing controls. The Block Design is a subtest of the Wechsler Intelligence Scales (e.g., WASI, WISC; Wechsler, 1999) in which the participant is asked to assemble an identical image of a 2-D picture, as fast as possible, using red and white blocks. When the pictures were pre-segmented, the controls' performance improved to a point where the group with autism was no longer superior. Shah and Frith suggested that participants with autism perceptually segmented the designs, such that presenting the designs pre-segmented provided no further benefit. The key features of both the Block Design Test and the Embedded Figures Test is that a figure can be segmented or include smaller constituent components; due to the drive for

central coherence in the typically developing population, the salience of these smaller components is not as great as the global figure. Frith (1989, 2003) argues that individuals with autism show better performance on these tasks because they lack a cognitive drive to attend to global form; that is, they have weak central coherence.

Additional support for WCC in autism has come from their superior performance on visuospatial and perceptual tasks relative to controls. In this context, Happe (1996) made a prediction about the lack of susceptibility to visual illusions, arguing that the reason people succumb to visual illusions is that they try to integrate all parts of the illusion as they process it. In the example of the Titchener illusion, where two comparison circles are physically identical in size, the presence of surrounding larger or smaller circles induces the misperception that the comparison circles are different in size. Happe (1996) found that participants with autism were less likely to succumb to visual illusions than other groups, arguing that individuals with autism processed parts of illusions in a piecemeal manner without integrating the comparison features with the inducing context.

Ropar and Mitchell (1999, 2001) discovered, in contrast to Happe (1996), that participants with autism were just as susceptible to visual illusions as controls. Ropar and Mitchell presented a variety of visual illusions to individuals with autism on a computer screen, and rather than asking if target elements were the same size or different, they asked participants to use computer keys to adjust stimuli to be the same size. The degree to which participants systematically erred on the task served as a measure of susceptibility. Surprisingly, participants with autism were susceptible to the illusions to the same degree as participants without autism. Milne et al. (2002) argue that findings

like those of Ropar and Mitchell (1999, 2001) suggest global processing seems to be under attentional control in autism and that care needs to be taken before concluding that autistic individuals have a low-level perceptual deficit (Milne et al., 2002). Another explanation is that higher-order processing is merely optional in autism but mandatory in people without autism (Mottron, Dawson, Soulieres, Hubert, & Burack, 2006), raising the possibility that whether or not higher-order processing is triggered depends on the wording of the question. In support of this explanation, Brosnan, Scott, Fox, and Pye (2004) reported that individuals with autism succumb to visual illusions (e.g., the Muller-Lyer illusion) when asked "which line *looks* longer", but not when asked "which line *is* longer."

As an alternative to WCC, Plaisted (2001) argues that perceptual processes in autism are better explained in terms of reduced generalization. Plaisted states that superior autistic performance on the Block Design and Embedded Figures Task can be explained as reduced processing of the similarities that are held between stimuli and situations. For example, in the Embedded Figures Task, the target contains some elements in common with the overall picture and features that define it. Hence, finding the target among the other patterns will be easier if the differences are more salient. The hypothesis that individuals with autism process unique features of stimuli relatively well and the common features poorly, gives rise to two complementary predictions. First, they should be better at difficult discrimination tasks in which the stimuli to be discriminated hold many elements in common and very few unique elements. Secondly, they should be poorer at tasks requiring the categorization of two sets of stimuli. This prediction is based on the theory that individuals with autism are better at processing the

difference between categories than shared category features. Support for the first prediction comes from a perceptual learning task (Plaisted, O'Riordan, & Baron-Cohen, 1998a) and a conjunctive visual search task (Plaisted, O'Riordan, & Baron-Cohen, 1998b). In the perceptual learning task, a typically developing adult group showed the perceptual learning effect: they were better at discriminating between familiar than novel stimuli. The group of adults with autism, however, did not show the perceptual learning effect and performed significantly better on the novel discrimination problem compared with the control adults. In the conjunctive search task, participants had to find a target stimulus (e.g., a red X) amongst two kinds of distracter stimuli which all shared one feature with the target (e.g., red Ts and Green Xs). Hence, the target stands out because of its combination of features; in order to find the target, participants have to be able to integrate the features. WCC theory predicts that participants with autism should be impaired on this task if they process the visual array in piecemeal and non-integrative ways, and hence should be slower at finding the target. However, the opposite was found: participants with autism were faster than typically developing individuals as predicted by Reduced Generalization theory. In support of the second prediction, that participants with autism should be poorer at a task that requires categorization of two sets of stimuli. Plaisted, O'Riordan, Aitken, and Killcross (2010) found that individuals with autism showed a deficit in initial category learning. Moreover, they found a reduced effect of categorizing according to the prototypes, that participants could induce from exposure to examples despite never having seen them before.

The hypothesis of weak central coherence among relatives of children with ASD and individuals in the general population has also been studied. Parents of children with

AS and fathers of children with ASD have shown a bias toward detail-focus in solving concerning visuo-spatial construction and problem solving (Baron-Cohen & Hammer, 1997; Happe et al., 2001), perceptual illusions (Happe et al., 2001), and verbal semantics (Happe et al., 2001). Parents of children with ASD performed significantly faster than parents of children with either intellectual impairment or early onset schizophrenia (Bolte & Poustka, 2006) in a test measuring local processing style, indicating weak central coherence. Briskman, Happe, and Frith (2001) administered social functioning questionnaires to members of 22 families with a child with autism and 15 families with a child with dyslexia in a study examining central coherence. This study found that those with relatives with autism preferred non-social to social activities more often than those with children with dyslexia. This study demonstrates an association between the BAP and WCC. Further, it suggests that WCC is related to social symptoms, which characterize autism in unaffected family members.

WCC is beginning to be investigated in typically developing samples. Grinter and collegues (2009) administered the EFT and Raven's Progressive Matrices to 55 undergraduates after they were each screened using the AQ to assess autistic traits. The study concluded that individuals with the highest number of autistic traits also displayed superior performance on the EFT and had the greatest amount of difficulty with global integration of visually presented stimuli. Taken together, these studies suggest that WCC holds promise as a cognitive phenotype related to autism and that this phenotype extends beyond the clinical boundaries of the diagnosis.

Autistic Cognitive Substrates in Typically Developing Samples

To date, only two studies have examined all three of these cognitive substrates in a typically developing sample. Kunihira, Senju, Dairoku, Wakabayashi, and Hasegawa (2006) administered the AQ to 1364 college students in Japan along with a battery of cognitive measures and personality inventories. Although the study found associations between autistic traits and obsessional personality, depression, and anxiety, there was no relationship between these traits and ToM, EF, or WCC. This finding may reflect a lack of sensitivity of the study's measures rather than the absence of these cognitive substrates. The study's authors theorized that their null findings might have resulted from a combination of low variability of autistic traits in the sample and the failure of the measures they selected to detect subtle differences. For example, the study used the Eyes Test as the sole measure of ToM. This measure is reliably able to distinguish those with ASD from those not meeting diagnostic criteria; its ability to detect within group differences in a typically developing sample is questionable (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 1997). Consequently, the use of ToM measures that more closely mimic real world social demands might reveal these differences. Additionally, single measures were employed to measure EF (WCST) and WCC (EFT). The use of multiple measures for each construct may increase reliability of measurement thereby increasingly the likelihood of detecting subtle differences. Similarly, the use of targeted recruiting techniques may address the issue of low variability of autistic traits. For example, recruiting based on characteristics associated with autistic traits (males, science majors) may increase the chances of obtaining a suitably diverse sample (Baron-Cohen et. al, 2001).

Best et al. (2008) administered the Social Communication Questionnaire (SCQ) to parents of 60 individuals between the ages of 13-22. These individuals were recruited from a sample of participants at heightened risk for mental illness due to learning problems. Individuals in the study were also administered measures of ToM, EF, and WCC. Counter to findings of Kunihira et al (2006), results indicated significant associations between all three cognitive substrates and autistic traits. This study also used two measures for each of the cognitive substrates. The study used first and second-order false belief tests to measure ToM, the Block Design Test and visual illusions to assess WCC, and ambiguous figure reversal to measure cognitive flexibility (EF). Although this battery is clearly more exhaustive than that used by Kunihira et al., it could be strengthened by the inclusion of ToM measures which approximate real world social demands and measures assessing more than one facet of each construct. Additionally, it can be argued that the sample used in this study should not be considered to be "typically developing" given their learning difficulties.

Given these disparate findings, further research should be conducted with truly typically developing samples and measures with sufficient sensitivity to detect subtle differences. Also, neither of the studies described above divided autistic symptoms into social and non-social types. Given the low observed correlations between these factors, not making this distinction may prevent detection of differences. Additionally, neither study related performance on these cognitive measures to broad social functioning. Because social functioning deficits are hallmark features of autism and frequent targets of treatment, the association of cognitive substrates and social functioning in typically developing groups should be explicitly explored.

Goals of the Current Study

The goal of the present study is to examine the relationships between autistic symptom domains (social and non-social symptoms), cognitive substrates related to autism (ToM, EF, WCC), and social functioning in a college sample. The study aims and hypotheses are as follows:

Aims and Hypotheses

Aim 1: Examine the relationship between sample demographic characteristics and degree of autistic traits.

The first aim is to examine the relationship between specific demographic variables and autistic traits. Studies have consistently found autistic traits to be more common among males than females (Baron-Cohen et al., 2001). Additionally, among college students, those majoring in laboratory sciences and computer science have been found to endorse autistic traits at rates higher than those of humanities and social science majors. It is, therefore, hypothesized that group differences will be observed for gender and undergraduate major, with males and laboratory science and computer science majors endorsing autistic traits at higher rates than other groups. Group differences are not expected with respect to other demographic variables (race, age, and year in school) as these differences have not been detected in past research.

Aim 2: Evaluate the relationship between social and non-social autistic symptom domains.

The second aim is to evaluate the relationship between social and non-social symptoms in the college sample. Ample evidence suggests that social and communication symptom domains are closely related in autism, but these domains tend

not to be related to non-social autistic symptoms (e.g., Happe and Ronald, 2007). The few studies that have examined this association in typically developing samples have produced similar findings, but these studies have been criticized due to the poor psychometric properties of measures used (Ronald et al, 2005, 2006). These findings point to a need for further evaluation of these relationships with psychometrically sound measures. It is hypothesized that social and communication autistic symptoms (social symptoms) will be positively associated with one another and that neither social nor communication autistic symptoms will be significantly associated with RRBI's (non-social symptoms).

Aim 3: Evaluate associations between social and non-social autistic symptoms and cognitive substrates related to autism (ToM, EF, WCC)

The third aim is to examine the associations between autistic symptom domains and cognitive substrates. Cognitive theories of autism were introduced in an attempt to explain the diverse symptoms seen in the disorder (Rajendran & Mitchell, 2007). These theories have been noted, however, for their inability to account for the full variety of autistic symptoms. The ToM hypothesis for example, appears to account for social and communication symptoms, but does not account for non-social symptoms among individuals with autism (Happe, 2001; Tager-Flusberg, 2007). Similarly, the EF hypothesis appears to explain the non-social elements of the disorder, but has been unable to plausibly explain the social elements (Happe & Ronald, 2007). The WCC hypothesis has the benefit of describing both some of the social symptoms and non-social symptoms, but the full explanatory scope of this theory has also been challenged (Happe & Frith, 2006). Based on the continuum theory of autism, the same patterns should be observed

in typically developing individuals. Specifically, it is hypothesized that: ToM will predict social and communication symptoms; EF will predict non-social symptoms; and WCC will predict both social and non-social symptoms.

Aim 4: Evaluate relationships between autistic symptoms, cognitive substrates, and social functioning.

The fourth aim is to evaluate the relationships between social and non-social symptoms, cognitive substrates (ToM, EF, WCC), and social functioning in a typically developing sample. The cognitive substrates have each been linked with social functioning among individuals with autism and first-degree relatives of individuals with autism (Bauminger & Kasari, 2000; Briskman, Happe, & Frith; Tager-Flusberg, 2000). If ToM, EF, and WCC are causally linked to social functioning and autistic symptoms, the symptoms should partially mediate the relationships between the cognitive substrates and social functioning. Specifically, it is hypothesized that the relationships between ToM and WCC and social functioning will be partially mediated by social autistic symptoms. Further, the relationships between WCC and EF and social functioning will be partially mediated by non-social autistic traits.

Figure 1 provides a visual representation of the hypothesized relationships outlined above.

CHAPTER 2: METHODS

Participants and Procedures

A sample of 70 undergraduate students at the University of North Carolina at Chapel Hill participated in the study. Table 1 provides sample demographic characteristics. Participants volunteered for the study in exchange for 2 hours of research participation credit in order to fulfill course requirements for Introduction to Psychology. Targeted sampling strategies were employed to insure sufficient range of scores on measures of autistic traits given the relatively small sample size. First, participation was restricted to males during a portion of the recruitment period. Although oversampling male participants reduces the generalizability of the study, it also increases chances of recruiting participants with autistic traits, as males are approximately twice as likely to possess these traits as females (Baron-Cohen et al, 2001). Additionally, individuals majoring in mathematics, laboratory sciences (chemistry, physics, biology), and computer sciences were specifically invited to participate. These individuals have been shown to be more likely to endorse autistic symptoms than those majoring in the arts, humanities, and social sciences (Baron-Cohen et al, 2001). In addition to these sampling strategies, autistic trait scores (Autism Spectrum Quotient) were reviewed after every 15 participants were collected in order to evaluate range of scores. Data was assessed with regard to range and skew of distribution to determine necessity of more restrictive sampling methods.

Exclusion criteria for the study were: 1) history of autism spectrum disorders among participants or first-degree relatives; 2) history of schizophrenia spectrum disorders among participants or first-degree relatives; 3) Scores in the autistic range on measures of autistic traits. Two individuals were excused from further participation after positive response regarding first-degree relatives with autism. One additional participant's data was not included in analysis after he scored in the autistic range on the AQ. Thus, sixty seven participants were included in final analyses. Demographic data obtained from each participant included age, race, GPA, and prior mental health diagnoses of the participant and first-degree relatives.

Participants read a brief description of the study aims and exclusion criteria and were able to sign up for a time slot to participate in the study through an online research enrollment system. Upon arrival, participants completed consent forms and a questionnaire for demographic information. A copy of the study consent forms is included in Appendix 2. Research assessments were conducted by the principal investigator and by trained undergraduate research assistants. After completing the assessments, participants were debriefed, apprised of study hypothesis, and thanked for their participation.

Measures

Autistic Traits

The Autism Spectrum Quotient (AQ; Baron-Cohen et al. 2001) is a 50-item self-report scale that measures characteristics of autism in the general population. Each item is rated on a 4-point scale, ''definitely agree","slightly agree","slightly disagree," and ''definitely disagree.'' Items are scored dichotomously as ''0'' or ''1'', with ''1''

representing answers in the direction of autism. Higher scores indicate a greater expression of the broader autism phenotype. Scores above 32 indicate likely diagnosis of ASD (Baron-Cohen, et al., 2001). The AQ has been found to have high internal consistency and test–retest reliability in college populations (Kunihira et al., 2006) and has been found to be a sensitive and valid measure of broad autism phenotype (Bishop, et al. 2008). The AQ contains five subscales, which represent domains of autistic behavior. These subscales also map roughly onto the autistic triad of social impairments, communication deficits, and RRBIs and will be used in the current analyses. This measure is included in Appendix 2.

The Broad Autism Phenotype Questionnaire (BAPQ; Hurley, Losh, Parlier, Reznick, & Piven, 2007) is a 36-item self-report measure designed to measure characteristics associated with the BAP in adult relatives of individuals with autism. Each item is rated on a 6-point likert scale with high scores representing more autistic traits. It is unique in being designed specifically to measure the BAP based on clinical observation of BAP characteristics in parents of children with autism. The BAPQ contains three subscales, which correspond to autistic symptoms domains: aloof personality, rigid personality, and pragmatic language/mind reading. A copy of this measure is found in Appendix 2.

The AQ was used as a screening measure to assess range of autistic symptoms. Both the AQ and BAPQ were used to evaluate the fractionability of the autistic triad (hypothesis 2). The BAPQ was used in the path analysis because the subscales of this measure map more directly onto the autistic symptom domains than do those of the AQ.

Cognitive Measures

The Hinting Task (Corcoran, 2001) is a self-report interview ToM assessment (although items are read to participants). This test contains ten short stories involving interactions between two people. Each story concludes with one of the characters uttering at statement with implied rather than explicit meaning (a hint). The participant's task is to determine the meaning of the hint. If not guessed correctly on the first trial, participants are given a second more direct hint about the meaning of the statement. Two points are awarded if the participant correctly deciphers the hint on the first trial. One point is awarded if the participant answers correctly after the second hint. No points are awarded if the participant is unable to determine the meaning of the hint after two trials. Performance is indexed as the total number of points with higher scores indicating better performance. The Hinting task has been found to reliably and validly index ToM abilities among typically developing young adults (Fernyhough, Jones, Whittle, Waterhouse, and Bentall, 2008). This measure is included in Appendix 2.

The Awareness of Social Inference Test (TASIT; McDonald, Flanagan, & Rollins, 2002) is a ToM assessment tool that comprises videoed vignettes of everyday situations enacted by professional actors. TASIT has three parts with alternate forms for re-testing. Part 2 will be used in this study due to its emphasis on discerning mental states of individuals during brief social interactions. This section is comprised of 15-videotaped vignettes designed to assess whether test participants are sensitive to conversational inferences and can, therefore, recognize that a person may say one thing and yet mean another. In each vignette, two adults are engaged in a conversation that is either sincere or sarcastic, e.g., "You have been a great help!" enacted sincerely or in a

manner that implies the opposite. The total number of correct responses indexes performance of the TASIT. Though the TASIT has not been used in samples with autism, its reliability and validity has been demonstrated with other clinical groups (McDonald, et al., 2002).

The Trail Making Test, part A and part B (TMT A, TMT B) (Reitan, 1958) was used to assess the EF domain of cognitive flexibility. In part A, the participant is asked to draw a line to connect consecutively numbered circles, and in part B to connect consecutively numbered and lettered circles alternating between the two sequences. Results are indexed by the amount of time needed for completion on each part of the measure with more time indicating poorer executive functioning skills. TMT B is one of the most widely used indices of executive functioning and excellent reliability as well as convergent validity with other measures of set shifting (Arbuthnott, 2000).

The EF domain of planning was measured using the Tower of London paradigm (Shallice, 1982). Specifically, participants are shown two pictures of rings on pegs and they have to denote how many moves of the rings will be needed in order for one picture to look like the other. Larger numbers of required moves selected denote poorer executive (planning) functioning. Studies suggest that this task is a valid measure of planning ability and is related to constructs such as independent living among those with intellectual disability (Masson, Dagnan, & Evans, 2010).

Perceptual WCC was indexed by performance on the Embedded Figures Test (EFT; Witkin, Oltman, Raskin, & Karp, 1971). On the EFT, participants are asked to locate a small target figure within a larger drawing of an everyday item. The time required to locate the target item is used as an index of performance with longer times

indicating worse performance. This measure has demonstrated adequate internal consistency and split-half reliability and has been used in studies with individuals with autism and unaffected family members of those with autism (Panek, Funk, & Nelson, 1980).

Visuospatial WCC was measured using the Block Design Task in segmented and non-segmented conditions (Wechsler, 2008). This task asks participants to assemble an identical image of a 2-D picture, as fast as possible, using red and white blocks. Individuals with autism have been shown to be faster than controls at constructing these patterns when presented with non-segmented stimuli. Time to completion, then, is taken as an index of piecemeal processing with shorter times suggestive of the autistic phenotype. Although this measure has not been widely used to index visuospatial WCC, it has been used in few studies including Best and colleagues (2007). The authors of this study concluded that this measure holds promise for use in studies with typically developing samples.

Social Functioning

Because social functioning is difficult to measure directly with self-report measures, a proxy construct closely related to social functioning was used in the path analytic model. Perceived social competence was assessed using the Interpersonal Competence Questionnaire (Buhrmester, et al., 1988). This 40-item questionnaire was designed to assess five domains of interpersonal competence: (a) initiating relationships, (b) disclosing personal information, (c) asserting displeasure with others, (d) providing emotional support and advice, and (e) managing interpersonal conflict. Each item of the ICQ briefly describes a common interpersonal situation. Respondents were instructed to

use Levenson and Gottman's (1978) 5-point rating scale to indicate their level of competence and comfort in handling each type of situation. Higher scores on this measure suggest greater perceived social competence. This measure has been shown to have excellent internal consistency and to be a reliable measure of social functioning in college samples (Muralidharan et al., 2010).

CHAPTER 3: RESULTS

Preliminary Analyses

Power analyses were conducted to determine the sample size necessary to detect significant findings in the regression model. For regression model with two sets of predictors, these analyses indicated that, to have an 80% chance of detecting an effect size of .2 at $p \leq .05$, a minimum sample size of 42 participants would be required (Cohen, Cohen, West, & Aiken, 2003). This effect size is comparable with those reported in similar studies such as those of Best and colleagues (2008). For the regression model with five sets of predictors, analyses indicated that, to have an 80% chance of detecting an effect size of .2 at $p \leq .05$, a minimum sample size of 57 participants would be required. Due to relatively small sample size, the path analytic model will be considered exploratory.

Demographic characteristics of the sample are displayed in Table 1. Descriptive statistics (mean, SD, range) were calculated for independent exogenous variables (ToM measures, EF measures, and WCC measures), mediating endogenous variables (autistic traits), dependent endogenous variables (social functioning) and for demographic sample information (age, race, major area of study, year in school).

Primary Analyses

Aim 1

The first study hypothesis predicted that male participants would endorse autistic traits at rates higher than those reported by female participants and that participants majoring in laboratory and computer sciences would endorse autistic traits at rates higher than those of participants majoring in humanities and social sciences. Based on past research, significant group differences were not expected with regard to other demographic variables (race, age, year in school). A series of One-Way ANOVAs were conducted to evaluate this hypothesis with demographic variables entered as independent variables with total AQ scores as independent variables.

Consistent with these predictions, significant group differences were found with regard to participant gender with male participants receiving higher scores on measures of autistic traits than women ($F(2,66)=3.00$; $p<.05$). Differences were also found with regard to major field of study ($F(4,64)= 3.52$; $p<.05$). Post hoc analysis revealed that those majoring in sciences and computer sciences endorsed higher levels of autistic traits than those majoring in the humanities ($F(4, 64) =3.77$; $p <.05$) and business ($F(4,64)= 3.69$; $p<.05$). No significant interactions were observed among these variables (See Table 3 for means by group).

Aim 2

The second study hypothesis predicted a significant association between social and communication autistic symptom domains, but not between these domains and RRBI's. To evaluate this hypothesis, composite variables of the three autistic symptom domains were created using the three subscales corresponding to these symptom domains

on the AQ and the BAPQ and bivariate correlations were calculated to assess association among the symptom domains. Resultant correlations are displayed in Table 4.

Consistent with expectations, significant correlations were observed between social and communication subscales on the AQ and BAPQ. Contrary to expectations, however, results also indicated significant correlations between these subscales and the non-social or RRBI scales. Specifically, on the AQ, Social and Communication subscales were significantly positively correlated with one another and were correlated with composite RRBI subscale (Attention to Details and Attention Switching subscales). On the BAPQ, Social and Communication subscales were significantly positively correlated with one another as were the Social and Rigidity subscales, and the Communication and Rigidity subscales. This pattern of results does not support hypothesis 2 and the fractionability of social and non-social traits.

Further analysis of correlational coefficients, however, indicated stronger associations between social and communication subscales than between these subscales and RRBI subscales. Steiger's t-tests for correlated or overlapping correlations were performed to assess differenced among the observed correlations. This test converts correlation coefficients using Fisher's Z transformation prior to computing the t statistic and significance testing. On the BAPQ, the observed correlation between Social and Communication subscales was found to be significantly stronger than those between the Social and RRBI subscales ($t=2.05$, $p<.05$) and Communication and RRBI subscales ($t=2.65$, $p<.05$). However, a comparison between these correlations on the AQ revealed that the Social and Communication subscales were not more closely related to one

another than the Social and composite RRBI subscales (t=1.36, p=.18) and Communication and RRBI subscales (t=1.28, p=.22).

Aims 3 and 4

To examine hypothesized relationships among autistic traits, cognitive substrates and social functioning while accounting for co-variation among predictors and outcomes, path analyses were conducted using full information maximum likelihood as implemented in MPlus version 6.11 (Muthen & Muthen, 2007). Prior to testing specific study predictions, the explanatory power of the full-predicted model was tested. The chi sqaure (χ^2) goodness-of-fit statistic is one of the most commonly used statistical tests within this framework, and indicates the degree of consistency between the pattern of fixed and free parameters, and the pattern of variances and covariances in the observed data. It tests the null hypothesis that the matrix estimated from the model parameters equals the observed data matrix. It should *not* be significant if there is good model fit. The Comparative Fit Index (CFI) and the Root Mean Squared Error of Approximation (RMSEA) will also be examined, given that they tend to be the least biased indices in small samples (Hu & Bentler, 1998). Both indices use conventional cut-offs to indicate good model fit.

Model fit statistics indicated an unsatisfactory fit of the data with the Social Competence Model (χ^2= 264.37, $p < .001$, RMSEA=.17, CFI=.80). Following this result, an iterative process was used to identify which paths might be removed to achieve satisfactory fit statistics. Further specification and removal of non-significant free parameters related to weak central coherence resulted in satisfactory fit (χ^2= 96. 69, $p>.05$, RMSEA=.047, CFI=.98). The resultant observed model is displayed in Figure 2.

Means, standard deviations, and ranges for measures of autistic traits, cognitive substrates, and measures of social functioning are also included in Table 2. After assessing overall model fit, individual paths were examined to determine their consistency with predictions of hypotheses 3 and 4.

The third study aim examined direct effects between cognitive measures and autistic traits. Our prediction of significant negative relationships between measures of theory of mind and social autistic traits was supported. The hinting task and TASIT were each observed to be negative predictors of social autistic traits. Additionally, and consistent with our hypotheses, measures of executive functioning were found to be significant predictors of non-social autistic traits. TOL scores were negatively associated with these traits while TMTB scores were positively associated with non-social traits. Finally, we predicted significant relationships between measures of weak central coherence and both social and non-social autistic traits. These predictions were not supported by the data. GEFT scores did not predict social autistic traits (β=-.09; p=.42) or non-social autistic traits (β=-.13; p=.31). Similarly, Block Design scores did not predict social autistic traits (β=-.05; p=.49) or non-social autistic traits (β=.02; p=.56).

The final hypothesis predicted that relationships between ToM and WCC and social functioning would be partially mediated by social autistic symptoms and that relationships between WCC and EF and social functioning would be partially mediated by non-social autistic symptoms. The bootstrapping method was used to evaluate the statistical significance of indirect effects. Bootstrapping is a non-parametric method based on resampling with replacement, which is done many times, e.g., 1000 times. From each of these samples, direct and indirect effects are computed and a sampling

distribution can be empirically generated. Because the mean of the bootstrapped distribution will not exactly equal the indirect effect, a correction for bias is usually made. With the distribution, a confidence interval, a *p* value, or a standard error can be determined. A confidence interval is computed and it is checked to determine if zero is in the interval. If zero is not in the interval, then the direct or indirect effect can be said to be present. The *p* statistic is used to test the null hypothesis that the direct or indirect effect is not present (Bollen & Stine, 1990; Preacher & Hayes, 2004; Shrout & Bolger, 2002).

Study predictions involving indirect effects received partial support. Results indicated that the relationship between Hinting Task scores and ICQ scores was partially mediated by BAPQ Social Scores (β=.13 ; *p*=.05) and that the relationship between TASIT scores and ICQ scores were also partially mediated by social traits (β=.14; *p*<.05). Partial mediation could not be assessed with regard to EF and WCC as these constructs were not found to be significantly associated with social functioning (TOL- β=.003; *p*=.94; TMTB- β= -.004; *p*=.58; GEFT β=-.04; *p*=.32; Block Design β=-.003; *p*=.42).

CHAPTER 4: DISCUSSION

The primary aim of this study was to explore autistic traits and predictors of these traits among a group of typically developing college students and to test a model of casual relationships between autistic symptoms, cognitive substrates, and social functioning. Consistent with expectations and with past research, demographic variables of gender and college major were related to autistic traits. Overall, men tended to score higher than women on the AQ and BAPQ, consistent with the findings of Baron-Cohen et al. (2001) and Wakabayashi (2003). This finding likely reflects the overrepresentation of autism and Asperger's syndrome in men (Happe & Frith, 1996; Wing, 1981), and is consistent with the extreme male brain hypothesis of autism (Baron-Cohen & Hammer, 1997; Baron-Cohen, 2002). Also consistent with previous work, participants majoring in laboratory sciences scored higher on measures of autistic traits than individuals majoring in the arts and humanities. This finding replicates previous work, which suggests a link between autism spectrum conditions and occupations/skills in math, physics, and engineering (Baron-Cohen et al., 1998).

Support was also found for the hypothesized association between social and communication autistic symptoms domains. Contrary to expectations, however, significant correlations were also found between these domains and the RRBI domain. Although these latter associations were not as strong as those found between social and communication domains (at least for the BAPQ), these findings do not support the

fractionability of the autistic triad in typically developing samples. One reason for this pattern of findings may be the broad manner in which the RRBI domain was assessed. This broadness is especially notable on the AQ which may account for the lack of significant differences between correlations among subscales on this measure. This domain, in general, is the most heterogeneous in the autistic triad and includes features such as insistence on sameness and repetitive sensory and motor behaviors. It is possible that this domain is further fractionable and that certain aspects of this domain correlate with social and communication symptoms while others do not. Although it is not possible to meaningfully further parse this domain with available measures, future factor analytic studies with larger sample sizes may shed light on this hypothesis.

Although significant associations between social and non-social symptoms were contrary to our hypotheses, this finding is consistent with those observed in samples of individuals with autism (Happe & Frith, 2000). These individuals, by definition, experience symptoms in all three-symptom domains. An important implication of hypothesized fractionability of the ASD triad in typically developing samples is that putative cognitive underpinnings (symptom domains) need not be specific to ASD. Rather, it is the combination of deficits that is unique to the disorder (Mandy & Skuse, 2008). Further explication of this finding may open the way to more research comparing different clinical groups, not only highlighting differences but also similarities in core deficits.

Overall, this study produced partial support for the predicted model of relationships among autistic traits, cognitive substrates, and measures of social functioning. The predicted model did not initially produce satisfactory model fit

statistics. Satisfactory fit statistics were achieved for the final model, however, by removing non-significant WCC pathways. It is unclear what accounted for the lack of association between WCC measures and measures of autistic traits and social functioning. One possibility, however, relates to restriction of range on these measures. The simplicity of these measures may have resulted in ceiling effects, which prevent significant associations with other variables. For example, most participants were able to complete all items on the GEFT and Block Design Task in the allotted time period. Different results may have been obtained if shorter time intervals had been used. Although such modifications alter the nature of these tasks, they may have allowed for detection of significant differences in typically developing samples where ceiling effects are likely. Similar problems have been noted in other studies using typically developing participants and measures designed for individuals with unique cognitive profiles (i.e., Kunihira et al., 2008). Another unexpected was the non-significant relationship between measures of executive functioning and social functioning. This finding may reflect the severity of executive functioning deficits necessary to produce social difficulties, which has been noted in past studies (e.g., Nyden, Hagberg, Gousse, & Rastam, 2010).

Consistent with expectations, however, ToM predicted social functioning scores and this relationship was partially mediated by social autistic traits. These findings suggest that these measures hold promise in evaluating sub-clinical social cognitive difficulties. This finding is notable given the inconsistent findings of previous studies with typically developing samples with regard to ToM. As described above, many of these studies have failed to detect differences among theory of mind abilities among typically developing individuals which is likely attributable to insufficient sensitivity of

first and second degree false belief tasks (Peterson & Siegal, 2003; Peterson, Slaughter & Mackintosh, 2007; Shaked, Gamliel, & Yirmiya, 2006). These tasks are vulnerable to ceiling effects when used in non-affected samples. Thus, a logical solution to this problem is the use of ToM measures that more closely mimic real world social demands. The Hinting Task and TASIT were selected based upon their ecological validity. Results suggest that these measures may be useful in future studies of typically developing samples.

Study Limitations and Directions for Future Research

The most significant limitations of the current study involve issues related to self-report measures of autistic traits and social functioning. These measures are susceptible to bias and issues related to impression management as individuals may be reluctant to endorse shortcomings or social failings. The study would have been bolstered by the inclusion of informant rated measures of cognitive substrates and autistic traits and by more objective measures of social functioning. The inclusion of such measures in future studies will help in clarifying associations between autistic traits and social functioning and the causal role of cognitive substrates associated with autism. Such studies hold important implications with regards to the manner in which autism is currently studied and conceptualized.

An additional limitation of the current study is that it did not include measures to insure participants' understanding of self-report questionnaires. Given that the study included individuals from a variety of cultural backgrounds, it is possible that some participants had difficulty understanding test items assessing nuances of social relationships and communication patterns. This limitation may be especially pronounced

for cases in which English was not a given participant's first or primary language. This limitation might be addressed in future studies by including measures of linguistic understanding or excluding participants for whom English is a second language.

Further validation of results found in this study will bolster the view that genetic and neuroimaging studies should study phenotypes based on cognitive substrates related to autism as an alternative to strict definitions of autistic disorder. This phenotypic approach offers a number of benefits with regard to research methodology. Chief among these advantages is expansion of participants taking part in autism research. Including individuals with sub-clinical ToM impairment (or other cognitive styles which can be reliably measured) in studies autism research studies greatly expands the potential participant pool compared with only including individuals diagnosed with the disorder. Although incidence of autism has risen steadily throughout the last several decades, it is still a relatively low incidence condition (Rutter, 2005). Studies with typically developing individuals may also allow for further characterization of genes contributing to autism. Additionally, studies with typically developing individuals may be helpful in determining genes or combinations of genes contributing to ToM ability (Nyden et al, 2011). Finally, a dimensional theory of autism may be associated with a reduction in stigma, as has been found in other disorders (Pescosolido, 2013). Continuing to characterize and define this dimensional understanding of autism holds promise in broadening the popular understanding of autism and decreasing negative reactions directed at individuals with the disorder.

Overall, the current study extends previous research in a number of regards. Unlike previous studies of cognitive substrates in typically developing individuals, the current

study employed multiple measures of each cognitive construct to account for their multidimensional natures. Additionally, the measures selected for the current study were chosen, in part, based on their similarity to real world demands. For example, performance based ToM measures were selected rather than false belief tasks due to their similarity with social demands and sensitivity to subtle differences in ability. Finally, a distinction between the current study and that of Best and colleagues (2008) relates to the manner in which the sample was selected. Best's sample was composed individuals with severe learning disabilities and may not be viewed as truly typically developing. The current study addresses the shortcomings of previous studies and provides partial support of the continuum hypothesis of autism spectrum disorder.

APPENDIX 1: DATA TABLES AND FIGURES

Table 1. Demographic Characteristics

	Mean (SD)	*Range*
Age	19.10 (1.07)	18-22
	%(Count)	
Gender (male)	62.7 (42)	
Ethnicity		
Caucasian	67.2 (45)	
African-American	17.9 (12)	
Asian	13.4 (9)	
Other	.01(1)	
Major		
Arts/Humanities	40.3 (27)	
Lab Science	26.9 (18)	
Computer Science/Math	17.9 (12)	
Business/Economics	14.9 (10)	
Year		
First Year	43.3 (29)	
Sophomore	28.4 (19)	
Junior	16.4 (11)	
Senior	11.9 (8)	

Table 2. Mean Autistic Trait, Cognitive Substrate, and Social Functioning Scores

	Mean (SD)	*Range*
Autistic Trait Measures		
AQ	15.15 (2.96)	5-27
BAPQ	94.05 (12.75)	58-121
ToM Measures		
Hinting Task	17.34 (2.18)	10-20
TASIT	54.06 (4.87)	38-60
EF Measures		
Tower of London Test	17.65 (2.79)	10-22
Trail Making Test- B	52.03 (19.34)	28-156
WCC Meaures		
Group Embedded Figures Test	13.51 (4.45)	0-18
Block Design Difference	47.67 (18.84)	3.10-162.88
Social Functioning Measure		
ICQ	142.59 (20.78)	86-190

AQ= Autism Spectrum Quotient, BAPQ=Broad Autism Phenotype Questionnaire,
TASIT= The Awareness of Social Inference Task
ICQ= Interpersonal Communication Questionnaire

Table 3. Mean AQ and BAPQ Scores by Group

	AQ *Mean (SD)*	BAPQ *Mean (SD)*
Gender		
Male	16.16 (5.87)	98.45 (11.25)
Female	14.28 (4.86)	89.34 (10.46)
Age		
18	14.43 (3.94)	92.05 (11.75)
19	15.36 (5.69)	94.25 (12.55)
20	15.54 (4.01)	95.34 (11.95)
21	14.33 (4.57)	92.35 (12.35)
22	15.50 (4.22)	96.55 (11.45)
Ethnicity		
African-American	15.25 (3.33)	94.25 (10.95)
Asian	15.67 (3.94)	95.50 (11.25)
Caucasian	15.65 (4.26)	96.55 (12.25)
Other	14.00 *	91.25*
Major		
Arts/Humanities	15.83 (4.72)	92.55 (11.55)
Lab Science	18.19 (5.49)	99.45 (15.25)
Computer Science/Math	19.26 (6.58)	105.55 (18.35)
Business/Economics	13.80 (5.31)	89.35 (10.25)
Year		
First Year	14.67 (4.93)	94.75 (11.25)
Sophomore	15.56 (5.28)	93.45 (10.95)
Junior	14.67 (5.65)	94.75 (12.45)
Senior	13.97 (5.39)	91.55 (11.35)

*- SD not computed; only 1 participant in this group.

Table 4. Correlations Among Autistic Trait Measure Subscales

AQ

	Social	Communication	RRBI
Social		.52**	.36**
Communication	.52**		.37**
RRBI	.36**	.37**	

BAPQ

	Social	Communication	Rigidity
Social		.61**	.38**
Communication	.61**		.32**
Rigidity	.38**	.32**	

**p<.01

Figure 1. Predicted Model

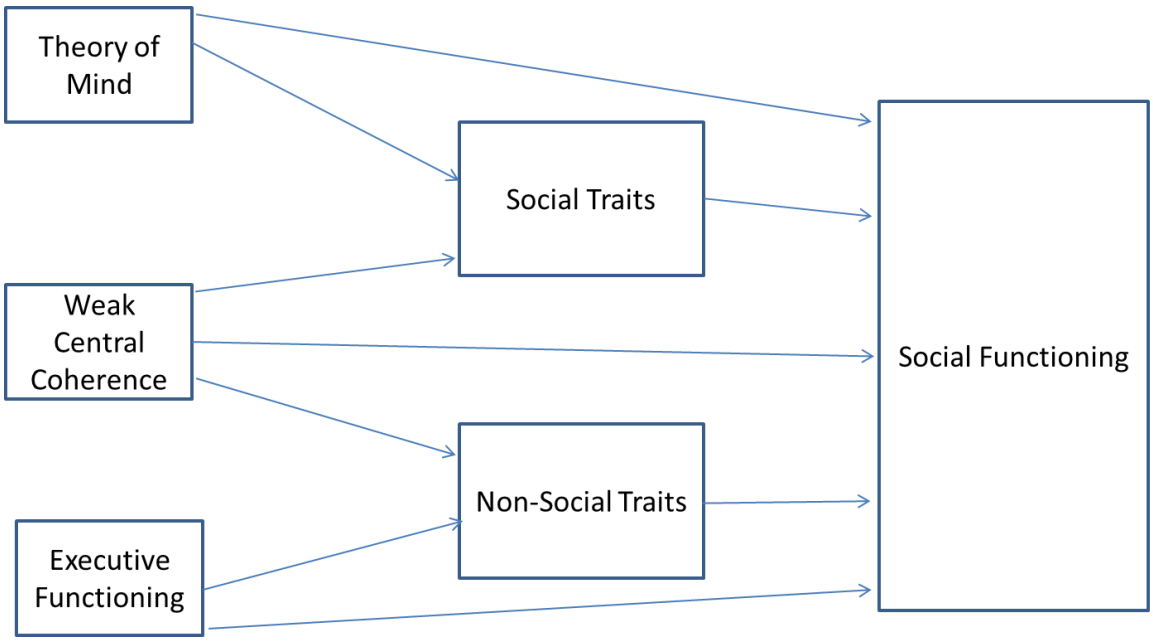
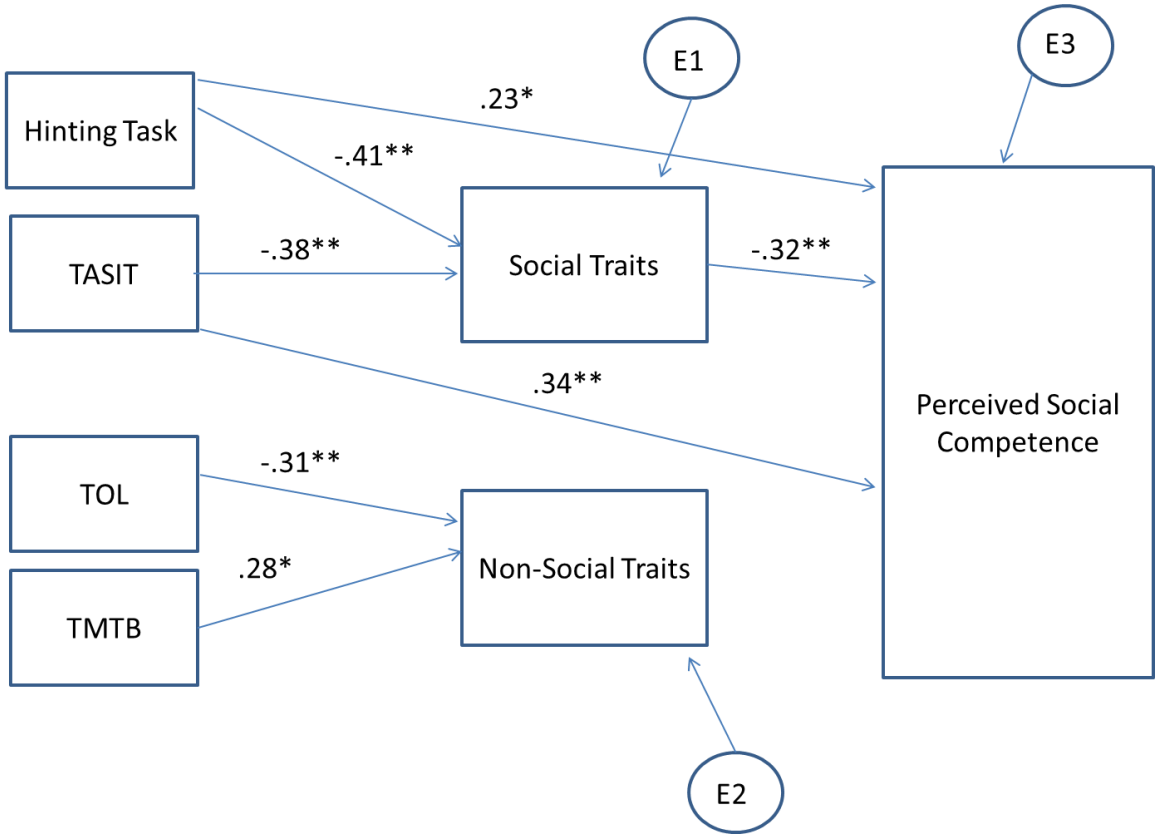


Figure 2. Observed Model



*p<.05
**p<.01

APPENDIX 2: CONSENT FORM AND STUDY MEASURES

University of North Carolina-Chapel Hill
Consent to Participate in a Research Study

IRB Study # 11-2292
Consent Form Version Date: 11/29/11

Title of Study: Relationships Between Sub-Clinical Autistic Traits, Cognitive Substrates, and Social Functioning in a Typically Developing College Sample

Principal Investigator: Timothy D. Perry, M.A.
UNC-Chapel Hill Department: Psychology
UNC-Chapel Hill Phone number: 919-593-5443
Faculty Advisor: David Penn, Ph.D

Study Contact telephone number: 919-593-5443
Study Contact email: tdperry@email.unc.edu

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may refuse to join, or you may withdraw your consent to be in the study, for any reason.

Research studies are designed to obtain new knowledge that may help other people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies.

Deciding not to be in the study or leaving the study before it is done will not affect your relationship with the researcher, your health care provider, or the University of North Carolina-Chapel Hill. If you are a patient with an illness, you do not have to be in the research study in order to receive health care.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study. You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?

The purpose of this research study is to learn about the association between autistic traits, cognitive patterns related to autism, and social functioning in a typically developing sample. The continuum theory of autism argues that the behavioral traits associated with the disorder are normally distributed throughout the population. Studies suggest that these traits can be reliably measured in first-degree relatives of individuals with autism and, more recently, in individuals in the general population. What remains unclear, however, is whether these traits in the general population are associated with similar cognitive and social profiles as those observed in autism. The current study will examine associations between autistic traits, cognitive substrates, and social functioning in a group of typically developing college students. Sixty male undergraduates will be recruited to complete self-report measures of autistic traits. Scores from these measures will be combined to create composite scores of social and non-social autistic traits. Participants will also complete a battery of measures related to cognitive theories of autism (theory of mind, executive functioning, and central coherence) and measures of social functioning and social support. Consistent with the continuum theory, we expect relationships among these variables to mirror those observed among individuals with autism. This study has implications related to the manner in which autism is conceptualized and treated.

Are there any reasons you should not be in this study?

You should not be in this study if you or one of your first-degree relatives (mother, father, or sibling) has received a diagnosis of autism spectrum disorder (autism, Aspergers Disorder, PDD-NOS) or schizophrenia spectrum disorder (schizophrenia, schizophreniform disorder, schizoaffective disorder).

How many people will take part in this study?

If you decide to be in this study, you will be one of approximately 60 people in this research study.

How long will your part in this study last?

Your participation in the study will involve one visit to the research lab on campus and should last for approximately 2 hours.

What will happen if you take part in the study?

You will be asked to complete a number of paper-and-pencil questionnaires. These questionnaires will include questions about your social involvement and personality traits. You may choose not to answer questions on these surveys for any reason.

You will also be asked to participate in interview and performance-based measures administered by the researchers. These measures will involve performing timed tasks and answering questions based on verbally presented or videotaped scenarios. As with the questionnaires, you are free to decline to answer questions or complete tasks for any reason.

What are the possible benefits from being in this study?

Research is designed to benefit society by gaining new knowledge. You will not benefit personally from being in this research study. You will, however, receive research participation credit for your involvement.

We hope that our research will make a significant contribution to the rapidly increasing literature on autism. This knowledge provides a framework for more effective educational programs, medical treatment and forms a basis for a more complete understanding of the assets, as well as difficulties, found in people with developmental disorders. The people who take part in research make an invaluable contribution to furthering our understanding of these conditions.

What are the possible risks or discomforts involved with being in this study?

Some of the questionnaire items deal with sensitive subjects such as sexuality and romantic relationships. These items may be embarrassing or produce mild discomfort. You are free to elect not to answer these items if you choose. You may also talk with the researchers regarding resources for handling potential discomfort should it arise.

What if we learn about new findings or information during the study?
You will be given any new information gained during the course of the study that might affect your willingness to continue your participation.

How will your privacy be protected?
Records of all participation in this research project will be maintained and kept confidential and will not be released without your prior written authorization. Any information we get from this study about you including your identity will be kept confidential.

We will take the following steps to ensure confidentiality. A research number will be assigned to you and your name will not be used. A linkage file joining the code with a name will be maintained in a secure location, accessible only to researchers working on this study. The results from the interviews and testing will not be released or shared in any way with any third party.

What if you want to stop before your part in the study is complete?
You can withdraw from this study at any time, without penalty. The investigators also have the right to stop your participation at any time. This could be because you have had an unexpected reaction, or have failed to follow instructions, or because the entire study has been stopped.

Will you receive anything for being in this study?

You will be receiving credit for research participation for taking part in this study.

<u>Will it cost you anything to be in this study?</u>
You will not be charged for any tests that are being performed for the purposes of this study. You will only be responsible for transportation to and from the research laboratory, which is located on campus.

<u>What if you are a UNC student?</u>
You may choose not to be in the study or to stop being in the study before it is over at any time. This will not affect your class standing or grades at UNC-Chapel Hill. You will not be offered or receive any special consideration if you take part in this research.

<u>What if you are a UNC employee?</u>
Taking part in this research is not a part of your University duties, and refusing will not affect your job. You will not be offered or receive any special job-related consideration if you take part in this research.

<u>What if you have questions about this study?</u>
You have the right to ask, and have answered, any questions you may have about this research. If you have questions, complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

<u>What if you have questions about your rights as a research subject?</u>
All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

- -

Title of Study: Relationships Between Sub-Clinical Autistic Traits, Cognitive Substrates, and Social Functioning in a Typically Developing College Sample

Principal Investigator: Timothy D. Perry

<u>Subject's Agreement:</u>

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

____ ___________________
Signature of Research Subject Date

____
Printed Name of Research Subject

_____ _____

Signature of Research Team Member Obtaining Consent Date

_____

Printed Name of Research Team Member Obtaining Consent

Autism Spectrum Quotient

Name:..... Sex:.....

Date of birth:..... Today's Date.....

How to fill out the questionnaire

Below are a list of statements. Please read each statement very carefully and rate how strongly you agree or disagree with it by circling your answer.

DO NOT MISS ANY STATEMENT OUT.

Examples

E1. I am willing to take risks.	definitely agree	slightly agree	slightly disagree	definitely disagree
E2. I like playing board games.	definitely agree	slightly agree	slightly disagree	definitely disagree
E3. I find learning to play musical instruments easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
E4. I am fascinated by other cultures.	definitely agree	slightly agree	slightly disagree	definitely disagree

1. I prefer to do things with others rather than on my own.	definitely agree	slightly agree	slightly disagree	definitely disagree
2. I prefer to do things the same way over and over again.	definitely agree	slightly agree	slightly disagree	definitely disagree
3. If I try to imagine something, I find it very easy to create a picture in my mind.	definitely agree	slightly agree	slightly disagree	definitely disagree
4. I frequently get so strongly absorbed in one thing that I lose sight of other things.	definitely agree	slightly agree	slightly disagree	definitely disagree
5. I often notice small sounds when others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
6. I usually notice car number plates or similar strings of information.	definitely agree	slightly agree	slightly disagree	definitely disagree
7. Other people frequently tell me that what I've said is impolite, even though I think it is polite.	definitely agree	slightly agree	slightly disagree	definitely disagree
8. When I'm reading a story, I can easily imagine what the characters might look like.	definitely agree	slightly agree	slightly disagree	definitely disagree
9. I am fascinated by dates.	definitely agree	slightly agree	slightly disagree	definitely disagree
10. In a social group, I can easily keep track of several different people's conversations.	definitely agree	slightly agree	slightly disagree	definitely disagree
11. I find social situations easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
12. I tend to notice details that others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
13. I would rather go to a library than a party.	definitely agree	slightly agree	slightly disagree	definitely disagree
14. I find making up stories easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
15. I find myself drawn more strongly to people than to things.	definitely agree	slightly agree	slightly disagree	definitely disagree
16. I tend to have very strong interests which I get upset about if I can't pursue.	definitely agree	slightly agree	slightly disagree	definitely disagree
17. I enjoy social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree

18. When I talk, it isn't always easy for others to get a word in edgeways.	definitely agree	slightly agree	slightly disagree	definitely disagree
19. I am fascinated by numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
20. When I'm reading a story, I find it difficult to work out the characters' intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
21. I don't particularly enjoy reading fiction.	definitely agree	slightly agree	slightly disagree	definitely disagree
22. I find it hard to make new friends.	definitely agree	slightly agree	slightly disagree	definitely disagree
23. I notice patterns in things all the time.	definitely agree	slightly agree	slightly disagree	definitely disagree
24. I would rather go to the theatre than a museum.	definitely agree	slightly agree	slightly disagree	definitely disagree
25. It does not upset me if my daily routine is disturbed.	definitely agree	slightly agree	slightly disagree	definitely disagree
26. I frequently find that I don't know how to keep a conversation going.	definitely agree	slightly agree	slightly disagree	definitely disagree
27. I find it easy to "read between the lines" when someone is talking to me.	definitely agree	slightly agree	slightly disagree	definitely disagree
28. I usually concentrate more on the whole picture, rather than the small details.	definitely agree	slightly agree	slightly disagree	definitely disagree
29. I am not very good at remembering phone numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
30. I don't usually notice small changes in a situation, or a person's appearance.	definitely agree	slightly agree	slightly disagree	definitely disagree
31. I know how to tell if someone listening to me is getting bored.	definitely agree	slightly agree	slightly disagree	definitely disagree
32. I find it easy to do more than one thing at once.	definitely agree	slightly agree	slightly disagree	definitely disagree
33. When I talk on the phone, I'm not sure when it's my turn to speak.	definitely agree	slightly agree	slightly disagree	definitely disagree
34. I enjoy doing things spontaneously.	definitely agree	slightly agree	slightly disagree	definitely disagree
35. I am often the last to understand the point of a joke.	definitely agree	slightly agree	slightly disagree	definitely disagree

36. I find it easy to work out what someone is thinking or feeling just by looking at their face.	definitely agree	slightly agree	slightly disagree	definitely disagree
37. If there is an interruption, I can switch back to what I was doing very quickly.	definitely agree	slightly agree	slightly disagree	definitely disagree
38. I am good at social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
39. People often tell me that I keep going on and on about the same thing.	definitely agree	slightly agree	slightly disagree	definitely disagree
40. When I was young, I used to enjoy playing games involving pretending with other children.	definitely agree	slightly agree	slightly disagree	definitely disagree
41. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	definitely agree	slightly agree	slightly disagree	definitely disagree
42. I find it difficult to imagine what it would be like to be someone else.	definitely agree	slightly agree	slightly disagree	definitely disagree
43. I like to plan any activities I participate in carefully.	definitely agree	slightly agree	slightly disagree	definitely disagree
44. I enjoy social occasions.	definitely agree	slightly agree	slightly disagree	definitely disagree
45. I find it difficult to work out people's intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
46. New situations make me anxious.	definitely agree	slightly agree	slightly disagree	definitely disagree
47. I enjoy meeting new people.	definitely agree	slightly agree	slightly disagree	definitely disagree
48. I am a good diplomat.	definitely agree	slightly agree	slightly disagree	definitely disagree
49. I am not very good at remembering people's date of birth.	definitely agree	slightly agree	slightly disagree	definitely disagree
50. I find it very easy to play games with children that involve pretending.	definitely agree	slightly agree	slightly disagree	definitely disagree

Broad Autism Phenotype Questionnaire

You are about to fill out a series of statements related to personality and lifestyle. For each question, write the number that best describes how often that statement applies to you. Many of these questions ask about
your interactions with other people. Please think about the way you are with most people, rather than special relationships you may have with spouses or significant others, children, siblings, and parents. Everyone changes over time, which can make it hard to fill out questions about personality. Think about the way you have been the majority of your adult life, rather than the way you were as a teenager, or times you may have felt different than normal. You must answer each question, and give only one answer per question. If you are confused, please give it your best guess.

1—Very rarely 2—Rarely 3—Occasionally 4—Somewhat often 5—Often 6—Very often

Questions:

____1. I like being around other people

____2. I find it hard to get my words out smoothly

____3. I am comfortable with unexpected changes in plans

____4. It's hard for me to avoid getting sidetracked in conversation

____5. I would rather talk to people to get information than to socialize

____6. People have to talk me into trying something new

____7. I am ''in-tune'' with the other person during conversation***

____8. I have to warm myself up to the idea of visiting an unfamiliar place

____9. I enjoy being in social situations

___10. My voice has a flat or monotone sound to it

___11. I feel disconnected or ''out of sync'' in conversations with others***

___12. People find it easy to approach me***

___13. I feel a strong need for sameness from day to day

___14. People ask me to repeat things I've said because they don't understand

___15. I am flexible about how things should be done

___16. I look forward to situations where I can meet new people

___17. I have been told that I talk too much about certain topics

___18. When I make conversation it is just to be polite***

___19. I look forward to trying new things

___20. I speak too loudly or softly

___21. I can tell when someone is not interested in what I am saying***

___22. I have a hard time dealing with changes in my routine

___23. I am good at making small talk***

___24. I act very set in my ways

___25. I feel like I am really connecting with other people

___26. People get frustrated by my unwillingness to bend

___27. Conversation bores me***

___28. I am warm and friendly in my interactions with others***

___29. I leave long pauses in conversation

___30. I alter my daily routine by trying something different

___31. I prefer to be alone rather than with others

___32. I lose track of my original point when talking to people

___33. I like to closely follow a routine while working

___34. I can tell when it is time to change topics in conversation ***

___35. I keep doing things the way I know, even if another way might be better

___36. I enjoy chatting with people ***

***Casual interaction with acquaintances, rather than special relationships such as with close friends and family members.

Hinting Task

ID #: _____ **Date:** _____

Instructions:
I am going to read you a set of ten stories involving two people. Each story ends with one of the characters saying something. After I've read the stories, I'm going to ask you some questions about what the character meant. Listen carefully to the story.

Scoring:
Score 2--if correct interpretation is given on first try. **Score 0**-- if response is a paraphrase of what the character said.
If incorrect response is given first, read the additional prompt. If correct on second trial--**Score 1**. Total possible score is 20.

	Scores	
	Response 1	**Response 2**

1. Long Journey
(George is tired and doesn't want to talk business immediately;
--OR-- He'd like a little rest and something to drink).

2. Dirty Bath
(Why didn't you clean the bathtub? --OR-- Please clean the bathtub).

3. Twinkies
(Can you buy me some twinkies, Mom? --OR-- I want twinkies).

4. Wrinkled Shirt
(Would you iron my shirt for me?)

5. Flat Broke
(Could you lend me some money? --OR-- Would you take me out tonight)

6. Work Project
(Will you give the project to me? --OR-- I'd like to do that project).

7. Birthday Present
(Would you buy me a puppy for my birthday?
--OR-- I want a puppy for my birthday).

8. Glassware
(Could you put the shelves up?)

9. Train Set
(Can we trade trains? --OR-- I want the red train).

10. Heavy Suitcases

(Could you help me with these suitcases?)

GRAND TOTAL:

1. George arrives in Angela's office after a long and hot journey down the highway. Angela immediately begins to talk about some business ideas. George interrupts Angela saying: My, My! It was a long, hot journey down the highway.

Question: What does George really mean when he says this?

Additional Prompt: George goes on to say, "I'm parched!"
Question: What does George want Angela to do?

2. Melissa goes to the bathroom to take a shower. Anne has just had a bath. Melissa notices that the bathtub is dirty so she calls upstairs to Anne, "Couldn't you find the Ajax, Anne?"

Question: What does Melissa really mean when she says this?

Additional Prompt: Melissa goes on to say, "You're very lazy sometimes Anne."
Question: What does Melissa want Anne to do?

3. Gordon goes to the supermarket with his mother. They arrive at the cookie aisle. Gordon says, "Wow! Those twinkies look delicious."

Question: What does Gordon really mean when he says this?

Additional Prompt: Gordon goes on to say, "I'm hungry Mom."
Question: What does Gordon want his mother to do?

4. Paul has to go to an interview and he's running late. While he is cleaning his shoes, he says to his wife, "Jane, I want to wear that blue shirt but it's very wrinkled."

Question: What does Paul really mean when he says this?

Additional Prompt: Paul goes on to say, "It's in the ironing basket."
Question: What does Paul want Jane to do?

5. Lucy is broke but she wants to go out in the evening. She knows that David has just been paid. She says to him, "I'm flat broke!" "Things are so expensive these days."

Question: What does Lucy really mean when she says this?

Additional Prompt: Lucy goes on to say, "Oh well, I suppose I'll have to miss my night out."
Question: What does Lucy want David to do?

6. Donald wants to run a project at work but Richard, his boss, has asked someone else to run it. Donald says, "What a pity, I'm not too busy at the moment."

Question: What does Donald really mean when he says this?

Additional Prompt: Donald goes on to say, "That project is right up my alley."
Question: What does Donald want Richard to do?

7. Rebecca's birthday is approaching. She says to her Dad, "I love animals, especially dogs."

Question: What does Rebecca really mean when she says this?

Additional Prompt: Rebecca goes on to say, "Will the pet shop be open on my birthday, Dad?"
Question: What does Rebecca want her Dad to do?

8. Betty and Michael moved into their new house a week ago. Betty has been unpacking glassware. She says to Michael, "Have you unpacked those shelves we bought, Michael?"

Question: What does Betty really mean when she says this?

Additional Prompt: Betty goes on to say, "If you want something you have to do it yourself!"
Question: What does Betty want Michael to do?

9. Jessica and Max are playing with a train set. Jessica has the blue train and Max has the red one. Jessica says to Max, "I don't like this train."

Question: What does Jessica want Max to do?

Additional Prompt: Jessica goes on to say, "Red is my favorite color!"
Question: What does Jessica want Max to do?

10. Patsy is getting off the train with three heavy suitcases. John is standing behind her. Patsy says, to John, "Gosh! These suitcases are a nuisance."

Question: What does Patsy mean when she said this?

Additional Prompt: Patsy goes on to say, "I don't know if I can manage all three."
Question: What does Patsy want John to do?

Interpersonal Competence Questionnaire

Please circle your response to each item based on the following scale:

1 = "I'm poor at this; I'd feel so uncomfortable and unable to handle this situation, I'd avoid it if possible";
2 = "I'm only fair at this; I'd feel uncomfortable and would have lots of difficulty handling this situation";
3 = "I'm OK at this; I'd feel somewhat uncomfortable and have some difficulty handling this situation";
4 = "I'm good at this; I'd feel quite comfortable and able to handle this situation";
5 = "I'm EXEXTREMELY good at this; I'd feel very comfortable and could handle this situation very well

1. Asking or suggesting to someone new that you get together and do something, (e.g., go out together)	1	2	3	4	5
2. Finding and suggesting things to do with new people whom you find interesting and attractive.	1	2	3	4	5
3. Carrying on conversations with someone new whom you think you might like to get to know.	1	2	3	4	5
4. Being an interesting and enjoyable person to be with when first getting to know people.	1	2	3	4	5
5. Introducing yourself to someone you might like to get to know (or date).	1	2	3	4	5
6. Calling (on the phone) a new date/acquaintance to set up a time to get together and do something.	1	2	3	4	5
7. Presenting good first impressions to people you might like to become friends with (or date).	1	2	3	4	5
8. Going to parties or gatherings where you don't know people well in order to start up new relationships.	1	2	3	4	5
9. Telling a companion you don't like a certain way he or she has been treating you	1	2	3	4	5
10. Saying "no" when a date/acquaintance asks you to do something you don't want to do.	1	2	3	4	5
11. Turning down a request by a companion that is unreasonable	1	2	3	4	5
12. Standing up for your rights when a companion is neglecting you or being inconsiderate.	1	2	3	4	5
13. Telling a date/acquaintance that he or she is doing something that embarrasses you.	1	2	3	4	5
14. Telling a date/acquaintance that he or she has done something that made you angry.	1	2	3	4	5
15. Confronting your close companion when he or she has broken a promise	1	2	3	4	5
16. Telling a companion that he or she has done something to hurt	1	2	3	4	5

your feelings.	
17. Revealing something intimate about yourself while talking with someone you're just getting to know	1 2 3 4 5
18. Confiding in a new friend/date and letting him or her see your softer, more sensitive side.	1 2 3 4 5
19. Telling a close companion things about yourself that you're ashamed of.	1 2 3 4 5
20. Letting a new companion get to know the "real you."	1 2 3 4 5
21. Letting down your protective "outer shell" and trusting a close companion.	1 2 3 4 5
22. Telling a close companion about the things that secretly make you feel anxious or afraid.	1 2 3 4 5
23. Telling a close companion how much you appreciate and care for him or her.	1 2 3 4 5
24. Knowing how to move a conversation with a date/acquaintance beyond superficial talk to really get to know each other.	1 2 3 4 5
25. Helping a close companion work through his or her thoughts and feelings about a major life decision, e.g., a career choice.	1 2 3 4 5
26. . Being able to patiently and sensitively listen to a companion "let off steam" about outside problems s/he is having.	1 2 3 4 5
27. Helping a close companion get to the heart of a problem s/he is experiencing	1 2 3 4 5
28. Helping a close companion cope with family or roommate problems.	1 2 3 4 5
29. Being a good and sensitive listener for a companion who is upset.	1 2 3 4 5
30. Being able to say and do things to support a close companion when s/he is feeling down.	1 2 3 4 5
31. Being able to show genuine empathetic concern even when a companion's problem is uninteresting to you.	1 2 3 4 5
32. When a close companion needs help and support, being able to give advice in ways that are well received	1 2 3 4 5
33. Being able to admit that you might be wrong when a disagreement with a close companion begins to build into a serious fight	1 2 3 4 5
34. Being able to put begrudging (resentful) feelings aside when having a fight with a close companion.	1 2 3 4 5
35. When having a conflict with a close companion, really listening to his or her complaints and not trying to "read" his/her mind.	1 2 3 4 5
36. Being able to take a companion's perspective in a fight and really understand his or her point of view.	1 2 3 4 5
37. Refraining from saying things that might cause a disagreement to build into a big fight.	1 2 3 4 5
38. Being able to work through a specific problem with a companion without resorting to global accusations ("you always do that").	1 2 3 4 5

39. When angry with a companion, being able to accept that s/he has a valid point of view even if you don't agree with that view.	1	2	3	4	5
40. Not exploding at a close companion (even when it is justified) in order to avoid a	1	2	3	4	5

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